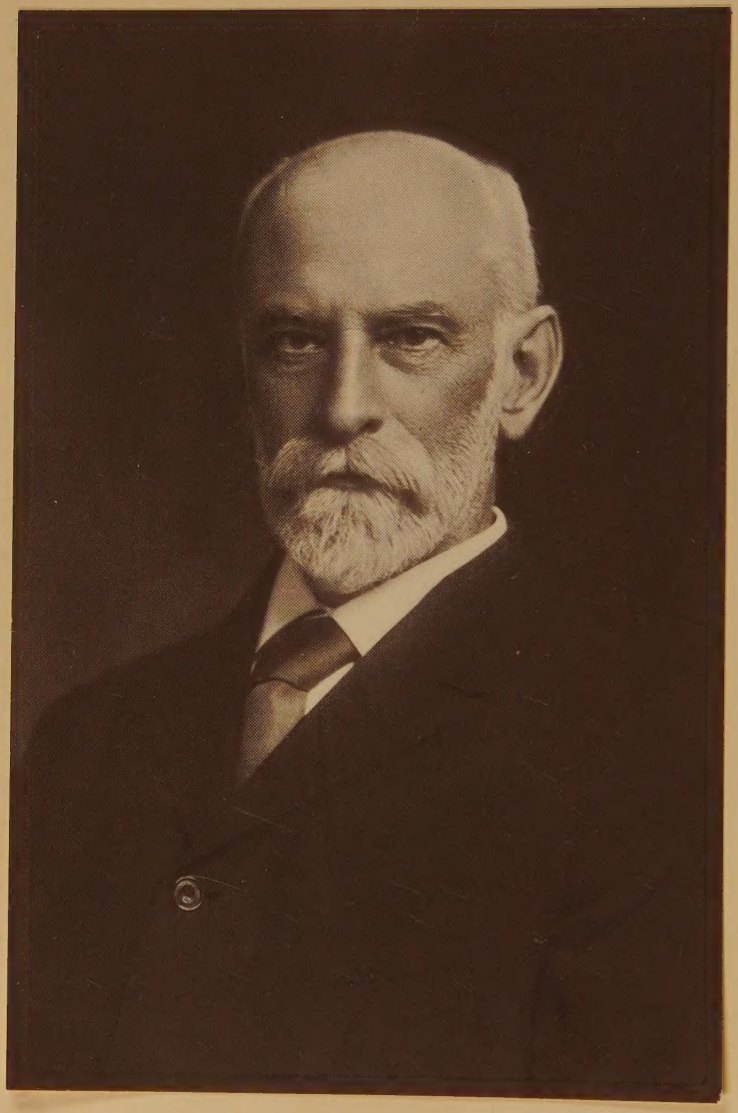

Charles S. Minot

CHARLES SEDGWICK MINOT

An address by Frederic T. Lewis, Vice-President of the American Association of Anatomists, delivered at the New Haven meeting of the Association, December 28, 1915.

The thirty-first session of the American Association of Anatomists, notwithstanding its large attendance, the excellence of the papers presented, and the notable hospitality of Washington University, was characterized by a pervasive sense of depression, due in part to the blighting effect of the European war and in part to the recent death of our leader—by common consent the foremost American anatomist. It is fittingly recorded in the minutes of that meeting, that as President and Member of the Executive Committee, his brilliant and constructive mind has guided the affairs of the Society with marked success, directing forward the long advance of national science. So broad were his biological interests that the physiologists also regarded him as of their number, and at the opening meeting of the American Physiological Society in St. Louis, Prof. Frederic S. Lee delivered a memorial address. At the same time, in Philadelphia, the American Association for the Advancement of Science expressed its sense of irreparable loss. These resolutions, and the impressive record of Dr. Minot's achievements as presented by Professor Cattell, the sensitive personal tributes of Professor Donaldson, the keen analysis of his work by Professor Porter, and the exposition of the mental and moral qualities which made him what he was, by President Eliot, are all before us; and yet this Association gladly sets apart a time for grateful reminiscence and informal consideration of one who was peculiarly our own.

Among the books which Dr. Minot read throughout, marking many passages, was Galton's *Hereditary Genius*. As recently as 1909, he wrote what is essentially a review of it, for publication in the Youth's Companion. "Ability of all orders tends to be

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inherited," he states at the outset, adding, "We commit, perhaps, no injustice towards Mr. Galton if we surmise that the theory first arose in his mind on the contemplation of his own family, many members of which are distinguished." Similar considerations may very reasonably have led to Dr. Minot's acquiescence, and doubtless he contemplated, with no little curiosity, the references to his own family history in the current magazines and works on eugenics.

Professor Minot's most distinguished ancestor was Jonathan Edwards (1703–1758), a graduate of Yale in the class of 1720. The historian, Fiske, declares that the more one considers Edwards the more colossal and astonishing he seems. He regards him as "one of the wonders of the world, probably the greatest intelligence that the Western Hemisphere has yet seen."

Although Professor Minot is in the fifth generation from Jonathan Edwards, their features, as seen in familiar portraits, have certain resemblances. Holmes describes Edwards as possessing "a high forehead, a calm steady eye, and a small rather prim mouth with something about it of the unmated and no longer youthful female." No reference is made to the rather long well-modelled nose, which is much like that of his descendant. Even though a beard conceals the mouth in Dr. Minot's portrait, there is altogether a comparable primness. But whether or not this facial resemblance is objective, these two relatives are alike in possessing the inquiring analytical mind of the naturalist. Professor Minot's early papers on insects may be compared with Edwards's astonishing paper on spiders, believed to have been written when he was not more than twelve years old.

On clear autumn days Edwards saw the air filled with shining webs and observed that—"Very Often there appears at the end of these Webs a Spider floating and sailing with them." In order to explain this flight he secured spiders of various sizes and provoked them to let out their webs. "In all Probability," he writes, "the web while it is in the Spider is a certain liquor with which that Great bottle tail of theirs is filld which immediately upon its being exposed to the air turns to a Dry Substance and very much rarifies." He saw the way in which the air currents caught the webs as they were let out and finally snapped them, so that from sticks held in his hand, the spiders

"mounted away into the air with a Vast train of Glistening web before them."

These beautifully accurate observations and experiments, recorded with sketches, amply justify Professor Packard's opinion that in another age and under other training Edwards might have been a naturalist of a high order.

Among all the available records left by Dr. Minot's ancestors, this manuscript of Edwards's alone shows the same type of mind, coupled with extraordinary ability and identity of interests. But is this more than a remarkable coincidence, of which the maze of genealogy presents so many examples? It must be admitted that Huxley's early dictum that the production of men of genius becomes hereditary, "not by physical propagation, but by the help of language, letters, and the printing press," sounds strangely antiquated. The descendants of Jonathan Edwards have been so conspicuously talented and intellectual that their family history has been carefully studied by genealogists. If their conclusions are to be accepted, the source of Professor Minot's ability should be sought not only in Jonathan Edwards but in Edwards's antecedents. Some assert that it came from Jonathan's mother Esther, but others revert to his grandparents—Richard Edwards, a merchant of Hartford, Conn., and Elizabeth Tuttle, his wife, who is credited with "the nervous, sensitive and excitable temperament of genius." Thus Dr. Davenport declares—"Had Elizabeth Tuttle not been, this nation would not occupy the position in culture and learning that it now does." (Heredity in Relation to Eugenics, p. 228.)

It is surprising that in order to show that the production of gifted men depends upon careful marital selection, this union which no eugenist could recommend is the most frequently cited American example. Without considering further the story of Elizabeth Tuttle, we may venture an opinion that her importance has been overestimated, and in regard to Dr. Minot we may ascribe to her that proportion of his inherited qualities which, according to Galton's law, she was entitled to transmit, namely $\frac{1}{16{,}384}$.

In addition to the Edwards family, Dr. Minot is descended from many others which are old and highly honored in New England. From the time when Col. Stephen Minot was selectman of the town of Boston and member of a committee to draw up its charter of incorporation, the Minots have been prominent as merchants and lawyers of Boston, always active for civic betterment. Dr. Minot's grandmother Minot was the daughter of Daniel Davis, Solicitor-General of Massachusetts, and granddaughter of Judge Davis of Barnstable, member of the Provincial Congress. On his mother's side, his grandfather, Charles Sedgwick, was a lawyer of Lenox, Mass., the son of Theodore Sedgwick, a friend of Washington, Senator from Massachusetts, and Speaker of the national House of Representatives. Dr. Minot's grandmother Sedgwick was the daughter of Hon. Josiah Dwight of Northhampton, State Treasurer of Massachusetts.

It may be of interest to note that although there were no anatomists among Dr. Minot's antecedents, Prof. Thomas Dwight was his fourth cousin; Dr. Leonard Williams and Dr. Minot were both descendants of Timothy Edwards; and George Lewis was a common ancestor of Dr. Minot, Dr. Winslow Lewis (an early demonstrator of anatomy), Dr. Warren Lewis, and the writer. Professor Kingsbury also is remotely a kinsman of Dr. Minot. But among Dr. Minot's progenitors there were neither anatomists nor physicians. Their predominant legal training and legislative services are very striking. Dr. Minot's deviation from the traditional occupation may be partly explained by the fondness for nature manifested by both of his parents.

Professor Minot's father, William Minot, was born in Boston. The tide-waters of the Charles afforded him excellent fishing and the occasional excitement of seeing a seal, as he has carefully recorded. In his biographical notes he writes—"I had a natural fondness for shooting, and as soon as I was old enough, I procured a small gun;" adding—"I am fortunate in that the taste for it has continued unabated in my old age." At Nantucket he once shot sixty-seven black-breasted plovers in a day, and at Swan Island, of ducks, one hundred and eight. Then in 1880, he published an admirable paper on game protection, advocat-

ing national as well as state legislation, which should be based on scientific knowledge and observation. He desired to see "a gradual extinction of the instinctive habit of pursuit and destruction." With evident satisfaction, he states that all his children acquired an early fondness for nature and out-of-door life. "My children's love of nature," Mr. Minot continues, "was developed by their mother's tastes. No day passed without her getting interest and pleasure from its out-of-door changes of expression and character. In our holidays she was our constant companion."

So it happened that Mr. and Mrs. Minot selected for themselves and their children a beautiful and extensive estate in West Roxbury. The place, a high plateau covered with a pine forest, was very secluded and quite in the country. For four miles, toward Dedham, the woods were almost continuous, and hardly a house was to be seen; birds of all kinds were abundant and in some summers, as Mr. Minot has recorded, "forty or fifty nests could be counted in our grounds." At Woodbourne, as this estate was named, Dr. Minot was born on the twenty-third of December, 1852.

It is interesting to note the varying degrees in which Mr. Minot's sons responded to their opportunities for studying and enjoying nature. All of them liked the country and William, the eldest, was a keen sportsman and his father's companion on many expeditions. Henry, who was younger than Charles, did not care to shoot or collect birds, but he studied them with great ability, and at seventeen, had completed his well-known book entitled *Land-Birds and Game-Birds of New England.* He was an accurate observer, and gave promise of a notable career in science, had such been chosen. But he became interested in the construction of railroads and was soon the youngest railroad president in the United States. To Charles alone did the beauty and the problems of organic life appeal with irresistible compulsion—not as a mere source of recreation, nor as an occupation which brooked a rival, but as the one great theme worthy of life-long study and devotion. This was more than his father had anticipated, and apparently with some apprehension, the

family observed what Professor Donaldson describes as "the serious way" in which he took his biology, and his adoption of a precarious profession.

It may be said that Dr. Minot began his scientific career in July, 1868, by joining the Boston Society of Natural History, then under the presidency of Jeffries Wyman, and including Scudder, Putnam, Hyatt, Packard, Verrill, Wilder and Morse among its officers. Although but fifteen years old, he became at once an active member, and the report of the September meeting of the Section on Entomology includes the following brief but correct communication:

> Mr. C. S. Minot stated that there were three broods of *Chrysophanus americanus*, one appearing early in May, the second in July and the third the last of August. The insects of the first brood differ from those of the other two in wanting the row of red spots on the under side of the secondaries.

In the following year he described the previously unrecorded male of *Hesperia metea* Scudd., a small butterfly which he had collected in Dorchester; and in another brief paper he considered the great difference in the number of species in various genera of insects, regretting that there were so many which contained only one, two, or three species. At this time his father wrote:

> I must add that Charles is thoughtful and industrious about the place and has worked some days like a beaver, doing a deal of sodding and re-graveling, and generally getting the place in good order. In fact he has had an unexpected eye to everything and is an argus after bugs, of course; but what did surprise me were two modest well-expressed and mature articles on scientific subjects published in one of the scientific journals. I saw them by accident; he didn't tell of them. I could scarcely believe he wrote them, they were so good.

In 1868, the year in which Dr. Minot joined the Society of Natural History, he was admitted to the Massachusetts Institute of Technology. It was required for admission that candidates should be sixteen years of age and should pass satisfactorily in arithmetic, algebra, plane geometry, English grammar and geography. Dr. Minot was admitted before he was sixteen. He could not have entered the Scientific School of Harvard Uni-

versity until he was eighteen; and although there was no age requirement for Harvard College, it is improbable that he could have passed the entrance examinations without longer preparation. These examinations included not only all the subjects required by the Institute (with the substitution of "reading English aloud" for English grammar), but also ancient history, both Latin and Greek grammar and composition, parts of the Iliad and the Anabasis, Caesar's Commentaries, selected orations of Cicero, and the whole of Virgil. Therefore, although natural history was such a flourishing department at Harvard, with Asa Gray and Louis Agassiz at its head, its approach was so guarded by requirements in classics, both before and after admission, that Dr. Minot chose the Institute; and since a natural history curriculum had not been established there, he selected chemistry as his major subject. Perhaps his most influential teacher at the Institute of Technology was Edward Pickering, the astronomer, who was then professor of physics. In his department Dr. Minot prepared a simple apparatus for micro-photography and made a number of pictures of the parts of insects. An account of this work is included in the Reports of the President and Departments of the Institute for 1871–72. Dr. Minot completed his course with a good record and received the degree of Bachelor of Science in 1872, being the youngest member of his class. He was always a loyal alumnus, and never approved of the Harvard A.B. as a preparation for scientific studies "unless that degree represents adequate courses in chemistry, physics, biology, French and German." In fact these courses, without the A.B. degree, seemed to him sufficient.

While an undergraduate, Dr. Minot continued to publish notes on entomology, including the description of several new species of geometrid moths, which were, perhaps, his favorite group. At the same time Dr. Minot was reading very carefully the great works on evolution. Huxley's *Man's Place in Nature* was given him by an aunt at Christmas, in 1869. On the blank pages at the end, he wrote a terse summary, beginning "Herein is shown —" and concluding "In fine, man, tho' at the head of the family, *is* an ape;" but he adds—"The structural formation of the or-

gans of speech is not herein treated of and examined," and he notes that the human brain-size consistent with sanity is greater than that of the gorilla and asks "how did man bridge this hiatus?" Doubtless Dr. Minot had read Darwin's Origin of Species and many other scientific works before this. Beginning in 1870 he kept a record, showing that with much of the best general literature, he read while at the Institute many numbers of Nature, Huxley's Lay Sermons and Elementary Physiology, Darwin's Descent of Man, Lubbock's Origin of Civilization, Tyson's Cell Doctrine and Alexander Agassiz's Marine Animals and the Embryology of the Star Fish. The effect of this early reading is evident throughout Dr. Minot's career. "It were wiser," he said, "to take out the mainspring from a watch than to eliminate evolution from biology." Of Darwin, he writes (1885) "We are already able to appreciate the directness and force of his intellect, his noble candor, and above all, his insatiable love of knowledge and research;" and Huxley, he declares, "has carried scientific writing to unsurpassed excellence. His Lay Sermons are masterpieces.

In the fall of 1872, having obtained the degree of B.S., Dr. Minot could enter the graduate school of Harvard College. There he became one of three candidates for the degree of S.D. in natural history, the others being his friend Faxon, the zoologist, and Shaler, the geologist. Unfortunately the records do not show what studies were taken. There was some work with Louis Agassiz, who had just returned from the Hassler expedition with an abundance of material, and at that time Dr. Minot read his Essay on Classification. In the following summer both Faxon and Minot were with Agassiz at Penikese. Apparently some botany was studied, for Gray's Lessons were read in February, but descriptive phanerogamic botany did not meet with Dr. Minot's approval. It happened, however, that Prof. Henry P. Bowditch had returned from Europe in 1871 and had established his physiological laboratory at the Harvard Medical School. Although Dr. Bowditch was considerably older than Dr. Minot, the families had always known each other, and perhaps it was personal acquaintance which led Dr. Minot to become

Bowditch's first research pupil. Admission to his laboratory was a revelation, and teacher and pupil became the warmest friends. Ever afterwards, Dr. Minot enjoyed Bowditch's sympathy, interest, and appreciation, to which he responded with life-long respect and admiration. The experiments which they performed dealt with "the influence of anaesthetics on the vasomotor centres," and the results were published in a joint paper in 1874. The experiments were probably largely by Minot, but as Dr. Porter states, the publication itself bears unmistakably the marks of Bowditch's style and hand.

Dr. Bowditch had recently returned from the laboratory of the renowned Carl Ludwig, and it can readily be inferred why Dr. Minot gave up, for the time being, his candidacy for the S.D. degree and set out for Leipzig in 1873. He had fulfilled one of the required three years of study.

At Leipzig in October, he began a long course of German reading, and entered at once upon his physiological studies under Ludwig. At Ludwig's suggestion, he investigated the formation of carbon dioxide in resting and active muscle, the results of which were published in 1876; and in later years he referred to Professor Ludwig as the greatest teacher of the art of scientific research whom he had ever known. But he did not limit his studies to physiology. In December of 1873, he had apparently begun his investigations with the distinguished professor of zoology at Leipzig, Rudolf Leuckart. These studies were chiefly on the structure and classification of the lower worms, and led to several publications. In December of this eventful year the death of Agassiz occurred in Cambridge, and Dr. Minot received a letter from his father containing the following interesting comments:

> You were among his last pupils. It is too soon for any just estimate of Agassiz's life and service to science, but no doubt he did more than any one else in this century to transplant to America enthusiasm for scientific investigation. Your own choice of life is probably as much due to his indirect influence as to any other source, except your predisposing tastes.
>
> Next Tuesday is your birthday—your majority. How thankful I am for your good character, high aims, and excellent promise, for your

affectionate disposition, love of home, and generous ambition! You have a bright prospect before you. Your labors will always have your heart in them, and your acquisitions will every day enlarge your horizon over the illimitable kingdom of Nature.

Throughout the spring of 1874 Dr. Minot remained at Leipzig, continuing his physiological and zoological studies, and reading von Baer's Entwickelungsgeschichte, which served as the foundation for his embryological work. Later, while in Germany, he read von Baer's autobiography and addresses, and regarded him henceforth as "the greatest embryologist." In the summer, however, work was laid aside for a pedestrian trip in Switzerland, with Mr. Faxon. Professor Mosso, a fellow student under Ludwig, was another of Dr. Minot's companions on such expeditions, and a close friend. This friendship doubtless led to the deep interest which Dr. Minot took in Italian literature, both general and scientific.

After another term at Leipzig, during which Dr. Minot read His's Unsere Körperform, he went to Paris in the spring of 1875, and studied some months with Ranvier. Here he learned important methods in histological technique which he applied to the study of the water-beetle Hydrophilus, and this work was published in the following year. He then returned to his headquarters at Leipzig, but spent the winter of 1875–76 at Würzburg in Professor Semper's laboratory. Here he studied Leydig's "invaluable Lehrbuch der Histologie" and made serial sections of worms, thus perfecting his training in histological technique. Finally he returned to Leipzig for the summer of 1876, and then, after three years of European study, back to Boston in the fall.

No time was to be lost. Dr. Minot proceeded to publish the results of his investigations in a variety of papers. An abstract of Dr. Lesser's lecture on auto-transfusion was sent to the Medical and Surgical Journal. The Society of Natural History listened to a paper on the classification of worms. In the American Naturalist, Leyser's primitive sliding microtome was described under the title, The sledge microtome; and two papers were devoted to an enthusiastic account of the study of zoology in Germany, with sweeping criticisms of American institutions. To ob-

tain the degree of S.D., however, another year of resident study was required, and it was specified that Dr. Minot should take a course in anatomy at the medical college and do further work in Dr. Bowditch's laboratory. It is probable that he took the course in gross anatomy, with human dissection, under Dr. Oliver Wendell Holmes, but the record is not definite, and it is evident that Dr. Minot did very little work in gross human anatomy. With Dr. Bowditch he performed experiments on tetanus, which were published in full. This research is characterized by Professor Porter as "ingenious, laborious, meticulous, a conscientious collection of crumbs left by those earlier at the feast." With

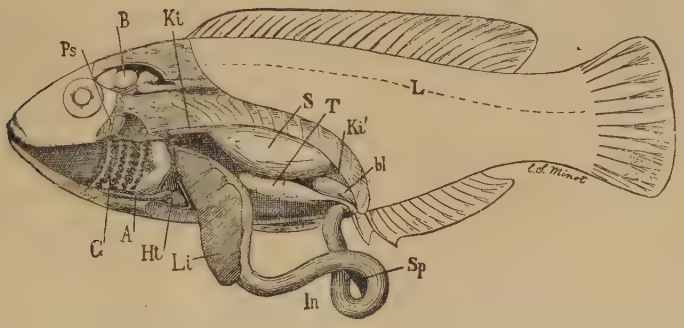

Fig. 1 "Anatomy of the Cunner, male." Drawn by C. S. Minot for Packard's "Zoology." (Henry Holt and Company, 1879.)

this array of publications, in place of the usual thesis, Dr. Minot took his final examination in 1878, and received the degree of Doctor of Science from Harvard University. Unfortunately the record of that interesting occasion was never written out by the secretary.

For two years after receiving his degree, Dr. Minot remained without any position and apparently was still uncertain as to what he should do. This interval, however, was spent in active scientific work. Professor Packard in 1879 published his Zoology, and to this Dr. Minot contributed a series of "engravings of the anatomy of vertebrates," one of which is here reproduced as an example of his early drawings. They were accompanied with

short accounts of the viscera shown in the dissections. Dr. Minot likewise collaborated with Professor Packard in writing the reports on the Rocky Mountain Locust, issued by the Entomological Commission at Washington. Dr. Minot's part was to describe the histology of the locust and cricket, and this is said to be his most important entomological work, still being used as a laboratory guide and book of reference.

In these years Dr. Minot began to formulate the great problem which was at the center of all his later work—an insoluble problem, but one which, as he declared, should be regarded as the object of all botanical and zoological studies. This is no less than the ultimate and essential nature of life. It was approached, in 1879, by stating the conditions to be filled by a theory of life. Consciousness, growth, senescence and rejuvenation, and heredity must all be explained in conformity with the cellular structure. Since this involves physiological and psychological studies, as well as those purely morphological, Dr. Minot made frequent excursions into other fields. But morphology was now his chosen science. He read scientific memoirs incessantly and announced that he was preparing a large work on comparative histology.

Up to the time of Dr. Minot's appointment as a lecturer at the Harvard Medical School (in 1880) his microscopic studies had been almost entirely of invertebrates. But he had proposed several new terms and radical hypotheses of general application. He had rejected Haeckel's gastraea theory, and had named the two-layered stage of the embryo, the *diaderm* (1877). In 1879, he stated that the primitive cells of the mesoderm are amoeboid in character, and for them he proposed the name of *mesamoeboids*. The sexual cells he called *genoblasts*, and his original hypothesis concerning them was illustrated by a diagram here reproduced as figure 2. All cells of the body were regarded as "hermaphrodite or neuter—sexless," since they contain both male and female elements (fig. 2, A). In producing a female cell, or *thelyblast*, Dr. Minot believed that the male elements, or *arsenoblasts*, were removed in several parts, which formed the polar globules (fig. 2, B). Adopting Kölliker's conclusion of 1847 that

spermatozoa arose in vesicles or cells, he considered that the male portion of such a cell became separated as several arsenoblasts or spermatozoa, leaving behind the nucleated remainder of the cyst as a female cell or thelyblast (fig. 2, C). By the union of an arsenoblast and thelyblast, a neuter cell, the fertilized ovum, would be produced. According to Wilson, "this ingenious view was independently advocated by Van Beneden in 1883," but for reasons now obvious it has been abandoned.

The appointments at the Harvard Medical School which Dr. Minot received in 1880 were "procured for him with some difficulty." Because of his scientific attainments he had the support of President Eliot. Professor Bowditch was his friend; and an uncle, Dr. Francis Minot, was Hersey Professor of the Theory and Practice of Physic. But there was opposition to the appoint-

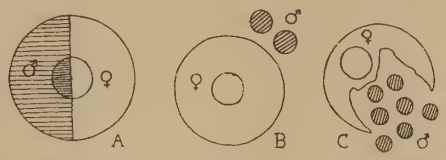

Fig. 2 "Diagrams to show the relation of the sexual products to cells. A, an ordinary cell; B, egg with polar globules; C, spermatocyst with spermatozoa." (American Naturalist, 1880, vol. 13, p. 106.)

ment on the Medical Faculty of one who was not a physician and who had no intention of becoming one, but who had for years been fitting himself to become a professional zoologist. Semper had taught Dr. Minot that "medical men are all spoilt zoologists," and Dr. Minot said significantly of Huxley—"He might have been a successful physician, but in that case what a rich vein of mental treasure would have been buried beyond recovery." So it resulted that Dr. Minot was given the absurd position of Instructor in Oral Surgery and Pathology in the dental school. At the same time he was appointed Lecturer on Embryology in the medical school, but without being admitted to the faculty.

From the catalogue of the dental school it appears that Dr. Minot's first class consisted of four students, who were taught the use of the microscope and the preparation of sections, in con-

nection with lectures on the finer structure and development of the teeth. At the medical school Dr. Minot gave a few lectures, but there was no separate examination in embryology. Instead, the subject was covered by the twentieth question on Professor Bowditch's paper, which reads—How is the pleuroperitoneal cavity formed in the embryo?

Year by year Dr. Minot increased the number of his lectures, and in 1883 he was appointed Instructor in Histology and Embryology. In the following year, with Dr. Quincy, he was in charge of laboratory exercises in histology twice a week, and his work at the dental school was then discontinued. In his first lecture after his appointment as instructor, he announced that embryology would "enable the student who has been seeking his way through the mazes of adult anatomy by sheer force of memory to have a mental picture which is at once clear, interesting and correct." In later addresses (1899) he expressed his conviction that "far more time is usually devoted to anatomy than is advantageous to the student;" and in 1890 he declared that unless the student betakes himself to embryology, his anatomy will be no better than "a stupid system of mnemonics." Doubtless enough has been said to show Dr. Minot's point of view toward medicine, and to explain why certain of his colleagues felt it their duty to prevent his control of the department of anatomy. Dr. Minot's first publication from the department of histology and embryology of the Harvard Medical School was on the seminal vesicles of guinea-pigs (in 1885), and the second was on the skin of insects. So Dr. Minot was reminded that the first duty of the medical school is to train practitioners of medicine. "A platitude," he replied, but in conversation he added—"Professors are very difficult to get along with; they not only have opinions, but have *reasons* for their opinions."

Gradually Dr. Minot's work changed, and conformed to a greater extent with that of a medical school. His studies on the classification of worms ended in 1885 with an account of the Vermes in the Standard Natural History, edited by his friend Professor Kingsley. In this same year Dr. Minot likewise completed his studies of the structure of insects, by writing an ac-

count of the anatomy of the cotton worm. Meanwhile most, but not all, his new species had 'gone into the synonymy' where he had helped to place others. In 1884, at the meeting of the American Association for the Advancement of Science, he urged a return to the Linnaean system of nomenclature, of which he says, "We have retained the form but rejected the principle." He believed that the present method of determining species was "thoroughly unscientific" and that "species will all have to be redetermined." His farewell to systematic zoology was expressed to Professor Kingsley in the following "original poem."

Classification is vexation,
Taxonomy is as bad;
Priority doth puzzle me,
And trinomials drive me mad.

An unexpected departure from anatomical studies occurred at this time. It was foreshadowed in 1880 in his review of Mosso's investigations, by means of a plethysmograph, of the changes in the circulation during cerebral activity. In this review Dr. Minot writes:

Although psychology is usually regarded as a department of philosophy, it is certainly more completely a natural science, since it deals with natural events, which are learned by direct observation, and which we coördinate by our reason . . . . During the new phase, into which psychology has apparently entered, the principal problems will probably concern the relation of mind to the substratum of matter in which it displays itself.

In 1884, he declared that to study scientifically the obscure and abnormal so-called psychical phenomena was a moral duty for those gifted with a clearer intelligence and purer moral sense. So he became a member of the organizing committee of the American Society for Psychical Research, and for the following review of his work in this direction we are indebted to Professor Yerkes.

To the study of telepathy, muscle reading, the number habit, superstitions, and other phenomena, Dr. Minot gave close and critical attention, bringing to bear upon the problems the thoroughness and impartiality of method which characterize all of his research.

During the ten years from 1884 to 1894, Professor Minot for the Society conducted a number of special investigations, the reports of which are of obvious scientific value. It is from them clear that he long remained open-minded and hopeful that important truth concerning 'mental action' might be revealed. Especially interesting are his reports on diagram tests and number habits. These show his admirable spirit of scientific research most effectively.

During the decade in question, his writings indicate that his attitude toward psychical research gradually changed, and in an article entitled The Psychical Comedy, published in 1895, in the North American Review, we find him reacting vigorously against the unscientific methods of psychical investigators. "It is foolish to search for marvels. The wise search for truth. Yet there are many who have done and are still doing the former, and in so far as they are seeking to find marvelous faculties of the human mind they are performers in the psychical comedy and their acts and opinions form the basis of this article."

Having become convinced by his contact with the members of the Psychical Research Society that their interest was not centered in the discovery of truth, Dr. Minot withdrew from psychical research, and our only evidence of the continuation of his interest in the problems of mental life is his presidential address before the American Association for the Advancement of Science, in Pittsburgh, in 1902. At this time he spoke of the problem of consciousness in its biological aspects in a way which at once revealed his keen interest in everything mental, and his conviction that the study of consciousness is an important duty as well as opportunity of biologists. It matters not that few psychologists, and still fewer biologists, can agree with all of his statements, for they are the utterances of one who thought honestly and vigorously along other lines than those of his daily work.

By his contributions to psychical research and to the general literature on consciousness (his papers number about a dozen), Professor Minot deserves to be ranked as an important contributor to our knowledge of mental phenomena. To the psychologist, most impressive of all is his insistence upon accuracy and reliability in observation and statement, and the evidence of his single-minded devotion to the truth.

In taking leave of psychical research, Dr. Minot published a characteristic statement, which involved him in amusing consequences. He said:

> The failure of psychical research should teach us a profound lesson—the lesson that literary training sets limits to the faculties. The leaders of the Psychical Society are literary men. . . .

To which Mr. Andrew Lang spicily replied in an article in the London News (Mar. 30, 1895) entitled "On a certain con-

descension in scientific men," showing that "literary training is not alone in limiting the faculties."

On many occasions Dr. Minot severely criticized his colleagues. When in 1883 he described Hubrecht's hypothesis of primogeniture as "pure speculation of that reckless quality which of late years has crept into zoology," and in 1886 referred to Flemming's new terms (including *mitosis*) as "new-fangled" and a burden to science, he was approaching "the bad-mannered fault-finding" which he perhaps repentantly denounced in an anonymous article—Youthfulness in Science (1889). His characteristic intensity of conviction was frequently vigorously expressed, and not always in such a way as to facilitate his progress.

In the year 1883, when Dr. Minot was appointed Instructor and took charge of the Department of Histology, the Harvard Medical School moved to its new building on Boylston Street—"a noble edifice," as Dr. Holmes declared, in which "you will find apartments devoted to microscopic instruction and study." These apartments included a well-lighted students' laboratory on the top floor which, according to President Eliot, was of Dr. Minot's own planning. It was equipped with eighteen Hartnack microscopes, and the department, we are told, was supported by an annual appropriation of fifty dollars, supplemented by a gift of six hundred dollars made personally to Dr. Minot and increased by his own generosity. Additional microscopes were purchased with money borrowed from the University and in time repaid through rental fees. This was done at Dr. Minot's suggestion, and the University was impressed not only with his vigorous teaching and many publications, but with his business qualities, so that in 1887 "it was possible to promote him to an Assistant Professorship in Histology and Embryology."

His inventive qualities were also now apparent, for in 1886, he had designed the rotary microtome, familiar to all histologists. Baltzer, the instrument maker for Professor Ludwig's laboratory, made the first one, but in 1888 they were being manufactured in Boston. The original form of this very valuable device is shown in figure 3. Its toothed wheel was small and therefore sections could not be cut thinner than 30 microns. Although

the 'precision microtome,' likewise designed by Dr. Minot (figured in Science, 1897, vol. v, p. 862), has largely replaced the rotary microtome in his own laboratory, especially for cutting serial sections of embryos, the rotary microtome is generally more widely used and is still of great service.

In the five years of his assistant professorship, Dr. Minot accomplished his most important scientific work, ending in 1892 with the publication of his remarkable treatise on Human Embryology, and his promotion to a full professorship. The Human

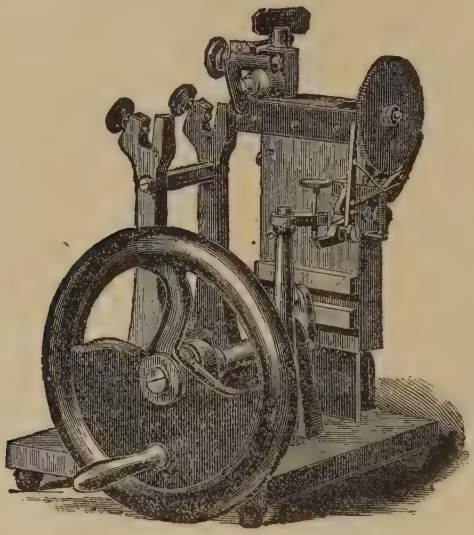

Fig. 3 "Minot's Automatic Microtome," as figured in the American Naturalist, 1888, vol. 22, p. 945.

Embryology, a volume of 815 pages, is described in the preface as the result of ten years' labor. It was an attempt "to present a comprehensive summary of embryology, as it bears upon the problems of human development," and it embodied the material previously published by Dr. Minot in a large number of papers. Two characteristics are most conspicuous. First, it is a masterly summary of an unwieldy literature, of which its author was in full command; and second, it is a presentation of a continuous succession of problems on which the author passes judgment in a manner compelling attention and wholly his own.

These features may be illustrated in the following paragraph which shows also the characteristic but distracting boldface references to the literature.

> The ORIGIN of the decidual cells (of the uterus) was long uncertain. Three views contended for acceptance: 1st, they are modified leucocytes (Hennig, Langhans just cited above, Sinèty **76**.**1**); 2d, they arise from the connective-tissue cells of the mucosa (Hegar and Maier, Leopold); 3d, they are produced by the epithelium. In favor of the first view, there has never been, to my knowledge, any evidence of importance. The second view has been definitely established by Minot, **98**, 429.

Dr. Minot's own paper, to which he here refers, was entitled Uterus and Embryo and was of great practical importance. It included a thorough consideration of the human placenta and membranes, based upon an extensive series of original preparations, and led the way toward utilizing sections of these structures in courses in histology for medical students.

In discussing the nature of sex, Dr. Minot still held to his theory of genoblasts already described. The chapter on blood embraces his work previously published in both the Anatommischer Anzeiger and the American Naturalist for 1895, which he summarized as follows:

> In the development of red corpuscles, we can distinguish three principal stages: 1, young cells with very little protoplasm; 2, old cells with much protoplasm and granular nucleus; 3, modified cells, with shrunken nucleus, which colors darkly and uniformly. I do not know whether the first form occurs in any living adult vertebrate, although the assumption seems justified that it is the primitive form. On the other hand, the second stage is obviously characteristic of the Ichthyopsida in general, while the third form is typical for the Sauropsida. Therefore the development of the blood-cells in amniota offers a new confirmation of Louis Agassiz' law (Haeckel's biogenetisches Grundgesetz).

This fundamental interpretation of the blood corpuscles appears to be well established. But it was followed by the adoption of Schäfer's opinion that the non-nucleated red corpuscles of mammals are intra-cellular protoplasmic products, which Dr. Minot names *plastids*. (Often we have seen Dr. Minot consult his Embryology to find, as he remarked, "opinions which I

once held".) In describing the liver, the accompanying figure was used (fig. 4) showing clearly the relations of the tubules to the large blood-channels which were later described as sinusoids, constituting another of Dr. Minot's far-reaching generalizations. The figure is from a drawing by Dr. Minot, and shows the simple nature of the illustrations used throughout the book.

The Human Embryology was immediately recognized as the most important work in its field which America had produced and the most noteworthy work in English since the publication

Fig. 4 Portion of a section of the liver of an Acanthias embryo of 29 mm. *hp*, hepatic cylinders; *bl*, blood-channels (later termed sinusoids). From Minot's Human Embryology, 1892, p. 761.

of Balfour's Comparative Embryology. In 1894, it was published in German translation, and Professor His, to whom Dr. Minot was indebted for generous permission to use his unique embryological collection in Leipzig, wrote the preface. In it he says that the book is substantial throughout, with the facts everywhere in the foreground. He adds, "Minot's work is at present the fullest human embryology which we possess . . . . and even after its contents in many parts shall have become superseded, it will retain its value as a bibliographical treasure-house." Dr. Minot's subsequent embryological publications are overshadowed by this masterpiece. They include

many well known papers, together with the Laboratory Text-book of Embryology. . In this text-book pig embryos were so described as to become the commonest objects of study in courses on mammalian embryology. This was of great service, as was also the establishment of his embryological collection. This collection of two thousand selected vertebrate embryos, cut in serial sections, has served for many investigations, and is a rich mine of opportunity for further work. The careful methods which were used in preparing and preserving these extensive series have served as a model in many laboratories.

The progress which Dr. Minot made toward a theory of life, which he had so early set forth as the ultimate goal of all biological work, is recorded in a series of papers of great interest. Influenced by Professor Bowditch's studies of the growth of children, Dr. Minot undertook a more comprehensive study of the growth of guinea-pigs. He was greatly impressed with the senescence, or loss of power to grow, manifested in infancy. Pushing his inquiries further, he concluded that the rate of growth was greatest in the segmentation of the ovum, and that it declined at such a rate that at birth 98 per cent of this power had been lost; and the remaining 2 per cent was largely exhausted in infancy. But before senescence conquers, the germ cells are set free, effecting rejuvenation. Having determined that there was a tremendous power of growth in the germ cells, which was lacking in those of the adult tissues, he sought for some corresponding difference in their morphological characteristics, and he thought that it was to be found in the proportionate bulk of nucleus and cytoplasm. In the young cells there is but little cytoplasm and correspondingly little functional differentiation. In the specialized cells of the adult, cytoplasm is abundant and differentiated, and death is the inevitable price which the organism must pay for the cytological differentiation on which all higher life depends. Cytomorphosis was the term which Dr. Minot used to designate these changes, and toward the close of his life he had planned further studies in this direction. Those which he had completed were published in his book on Age, Growth, and Death, which has received wide-spread recog-

nition, and of which a Japanese translation has recently been issued.

Such are the contributions to science which established Dr. Minot's position as the foremost American anatomist of his time. But as Galton has found, "some eminently scientific men have shown their original powers by little more than a continuous flow of helpful suggestions and criticisms, which were individually of too little importance to be remembered in the history of Science, but which in their aggregate formed a notable aid towards its progress." In this respect also, it is important to record the distinguished services of Dr. Minot, for not only in private, through extensive correspondence, but as president of societies, through stirring addresses, and as an organizer of scientific activity, his influence was powerfully felt throughout the country. He exalted the work of the scientist as few scientists would venture to do, but this he regarded as a duty. He declares that "until it is clearly recognized that the greatest crime of the French revolution was not the execution of the king but the execution of Lavoisier, there is no right measure of values, for Lavoisier was one of the three or four greatest men France has produced." It has been suspected that "in his heart, Dr. Minot concealed a regret that he could not become a philosopher," but this is far from true. "Philosophy," he says, "is ever a laggard and a follower after her swifter sister, Science." "Let us part company from the horde of foolish thoughts which have too long masqueraded under the false garb of philosophy." "Observation," he says "is the foundation of knowledge and no human knowledge is built on any other foundation." So Dr. Minot declares that "the applications of the invention of placing pieces of glass of particular shapes in the two ends of a brass tube have more profoundly influenced human thoughts and beliefs than any other single invention, excepting only printing. The telescope has revolutionized our conception of the universe, the microscope our conception of life."

The significance and difficulties of correct microscopic observation he believed to be very generally underestimated. Professor His has said that a keen *mind* is a common possession in

comparison with keen *vision;* but Dr. Minot goes further. It is conceit, he declares, which leads one to ascribe his failure to observe to poor vision. The retina is good—it is the brain which fails the poor observer. "Accurate observation," he repeats "is by far the most difficult art which mankind ever essayed." In this spirit he met his colleagues in annual convention, always genial and happy, persuading them that they were the salt of the earth. So also he met his classes of students, showing them how differently science may be regarded. Schiller says of Science:

> To one she is divine—a heavenly goddess; to another
> A good cow, providing him with butter.

Dr. Minot's message was always to those who looked upon medicine as more than a means of livelihood. For himself, science was enthroned on high, and faithful scientific research was Christian service.

It is very gratifying that academic distinctions were so liberally conferred upon Dr. Minot. He received the honorary degrees of Doctor of Laws from Yale in 1899; Doctor of Science from Oxford in 1902, Doctor of Laws from Toronto in 1904, and from St. Andrews in 1911. In his exchange professorship with Germany in 1912–13, which was likewise an honor conferred upon him, he represented not only Harvard University, but the anatomists of America, and he took no less pleasure in presenting the work of his colleagues than in describing his own researches.

His death occurred on the 19th of November, 1914, and by vote of the Association of Anatomists at the following meeting, the foregoing memorial of Doctor Minot's personal and academic life, with due consideration of his education and scientific achievements, has been prepared. Of necessity it is a very imperfect record. But it is hoped that it may show how a great anatomist arose among us, and how as President Eliot has said, "by clear merit he made his way." Every encouragement should be given to any youth of similar possibilities, and this Association exists primarily for that purpose,—but where can we find him?

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PROCEEDINGS OF THE AMERICAN ASSOCIATION OF ANATOMISTS

THIRTY-SECOND SESSION

At the Osborn Zoological Laboratory of Yale University, New Haven, Conn., December 28, 29 and 30, 1915

Tuesday, December 28, 9.30 a.m.

The thirty-second session of the American Association of Anatomists was called to order by President G. Carl Huber, who appointed the following committees:

Committee on Nominations for 1916: R. R. Bensley, chairman; F. T. Lewis, J. B. Johnston.

Auditing Committee: C. M. Jackson, chairman; S. Walter Ranson.

The morning session for the reading of papers concluded with an address by the Vice-President, Professor F. T. Lewis, A biographical sketch of Professor Minot.

Wednesday, 12.30 p.m., Association Business Meeting, President G. Carl Huber, Presiding.

The Secretary reported that the minutes of the Thirty-first Session were printed in full in The Anatomical Record, volume 9, number 1, pages 35 to 143, and asked whether the Association desired to have the minutes read as printed. On motion, seconded and carried, the minutes of the Thirty-first Session were approved by the Association as printed in The Anatomical Record.

Prof. C. M. Jackson reported for the Auditing Committee as follows: The undersigned Auditing Committee has examined the accounts of Dr. Charles R. Stockard, Secretary-Treasurer

of the American Association of Anatomists and finds the same to be correct with proper vouchers for expenditures and bank balance on December 21 of $264.09. (Signed) C. M. Jackson, S. W. Ranson, New Haven, Conn., December 29, 1915.

The Treasurer made the following report for the year 1915:

Balance on hand December 23, 1914, when accounts were last audited	$285.85	
Receipts from dues 1915	1693.81	
Total deposits		$1979.66
Expenditures for 1915:		
Postage	33.00	
Printing and Stationery	37.25	
Collection and Exchange	2.32	
Expenses of Secretary-Treasurer, St. Louis Meeting	90.00	
Wistar Institute for subscriptions, Jour. Anat., and Anat. Record	1546.00	
Return on over paid check	2.50	
Debit unhonored check	4.50	
Total expenditures, 1915		1715.57
Balance on hand		$264.09

Balance on hand, deposited in the name of the American Association of Anatomy in the Corn Exchange Bank, New York City, December 21, 1915.

On motion the reports of the Auditing Committee and the Treasurer were accepted and adopted.

The Committee on Nominations, through its Chairman, Prof. Ross G. Harrison, placed before the Association the following names: For President, Prof. Henry H. Donaldson; for Vice-President, Prof. Clarence M. Jackson; for members on the Executive Committee, terms expiring in 1919, Prof. Eliot R. Clark and Prof. Reuben M. Strong.

On motion, the Secretary was instructed to cast a ballot for the election of the above-named officers.

The Secretary presented the following names recommended by the Executive Committee for election to membership in the American Association of Anatomists:

Leslie B. Arey, Ph.D., Instructor in Anatomy, Northwestern University Medical School, *2421 Dearborn Street, Chicago, Illinois.*

Charles Bagley, Jr., M.D., Phipps Institute, *Johns Hopkins Hospital, Baltimore, Maryland.*

George Alfred Baitsell, Ph.D., Instructor in Biology, *Yale University, New Haven, Connecticut.*

Charles W. Bonney, A.B., M.D., Demonstrator in Anatomy, *Jefferson Medical College, Philadelphia, Pennsylvania.*

John W. Broadnax, Ph.G., M.D., Associate Professor of Anatomy, *Medical College of Virginia, Richmond, Virginia.*

Charles Brookover, Ph.D., Professor of Anatomy, *University of Arkansas, Little Rock, Arkansas.*

Louis Casamajor, B.A., M.D., Assistant Professor of Neurology, Columbia University, *437 West 59th Steeet, New York City.*

Harold Saxon Burr, Ph.B., Ph.D., Instructor in Anatomy, School of Medicine, *Yale University, New Haven, Connecticut.*

Robert Chambers, Jr., A.M., Ph.D., Assistant in Anatomy, *Cornell University Medical College, New York City.*

Charles Manning Child, Ph.D., Associate Professor of Zoölogy, *University of Chicago, Chicago, Illinois.*

Wesley R. Coe, Ph.D., Professor of Biology, *Sheffield Scientific School, Yale University, New Haven, Connecticut.*

Edgar Davidson Congdon, Ph.D., Assistant Professor of Anatomy, Leland Stanford University, School of Medicine, *330 Coleridge Avenue, Palo Alto, California.*

Wera Danchakoff, M.D., *Rockefeller Institute, New York City.*

Samuel Randall Detwiler, Ph.D., Assistant in Biology, *Yale University, New Haven, Connecticut.*

D. H. Dolley, M.D., Professor of Pathology, *University of Missouri, Columbia, Missouri.*

Jules Duesberg, M.D., Research Associate, Carnegie Institution of Washington, *Johns Hopkins Medical School, Baltimore, Maryland.*

J. H. Globus, B.A., Assistant in Anatomy, *Cornell University Medical College, New York City.*

Francis Wenger Heagey, A.B., M.D., Instructor in Anatomy, Columbia University, *437 West 59th Street, New York City.*

James Peter Hill, D.Sc., F.R.S., Todrell Professor of Zoölogy and Comparative Anatomy, University of London, *University College, Gower Street, London, W. C., England.*

Arthur Hofewell-Smith, L.R.C.P., M.R.C.S., L.D.S., Professor of Dental Histology Histo-Pathology, Comparative Odontology, *University of Pennsylvania Dental College, Philadelphia, Pennsylvania.*

Arthur Keith, M.D., LL.D., F.R.C.S.,F.R.S., Hunterian Professor of Anatomy, *College of Surgeons, London, England.*

John D. Kernan, Jr., A.B., M.D., Assistant in Anatomy, Columbia University, *437 West 59th Street, New York City.*

J. A. Key, B.S., Instructor in Anatomy, *Creighton Medical College, Omaha, Nebraska.*

Hugh McMillan Kingery, A.M., Instructor in Histology and Embryology, *Cornell University, Ithaca, New York.*

William Barri Kirkham, Ph.D., Instructor in Biology, *Sheffield Scientific School, Yale University, New Haven, Connecticut.*

Henry Laurens, Ph.D., Instructor in Biology, *Yale University, New Haven, Connecticut.*

Clarence E. McClung, A.M., Ph.D., Professor of Zoölogy, *University of Pennsylvania, Philadelphia, Pennsylvania.*

M. M. Miller, Ph.D., Instructor in Anatomy, *Vanderbilt University Medical School, Nashville, Tennessee.*

Mae Lichtenwalner Myers, M.D., Associate Professor of Anatomy and Director of the Laboratories of Histology and Embryology, *Woman's Medical College of Pennsylvania, North College Avenue and 21st Street, Philadelphia, Pennsylvania.*

Theophilus S. Painter, Ph.D., Instructor in Biology, *Sheffield Scientific School, Yale University, New Haven, Connecticut.*

George Papanicolaou, Ph.D., M.D., Assistant in Anatomy, *Cornell University Medical College, New York City.*

Charles W. M. Poynter, B.S., M.D., Professor of Anatomy, *College of Medicine, University of Nebraska, Omaha, Nebraska.*

Sidney Sigsfried Schochet, M.D., Instructor in Anatomy, *Dartmouth Medical School, Hanover, New Hampshire.*

John W. Scott, A.M., Ph.D., Professor of Zoölogy, *University of Wyoming, Laramie, Wyoming.*

M. DeForest Smith, A.B., M.D., Assistant in Neurology, Columbia, University, *437 West 59th Street, New York City.*

Chester A. Stewart, A.M., Assistant in Anatomy, *University of Minnesota, Minneapolis, Minnesota.*

Alaric Collender Sutton, A.B., Student, *Johns Hopkins Medical School, Baltimore, Maryland.*

F. J. Taintor, M.D., Assistant Professor of Anatomy, *St. Louis University, St. Louis, Missouri.*

Joseph M. Thüringer, M.D., Assistant in Histology and Embryology, *Harvard Medical School, Boston, Massachusetts.*

Richard Watkin Watkins, B.S., Assistant in Anatomy, *University of Chicago, Chicago, Illinois.*

James Crawford Watt, B.A., M.B., Lecturer in Anatomy, *University of Toronto, 20 Hawthorne Avenue, Toronto, Canada.*

Theodora Wheeler, A.B., Medical Student, *Johns Hopkins Medical School, Baltimore, Maryland.*

George Bernays Wislocki, A.B., Student, *Johns Hopkins Medical School, Baltimore, Maryland.*

On motion the Secretary was instructed to cast a ballot for all the candidates proposed by the Executive Committee. Carried.

Professor Harrison announced to the Association the death of Prof. Moritz Nussbaum which occurred on November 16.

Following this announcement President Huber appointed a Committee: R. G. Harrison, chairman; W. H. Lewis, W. M. Baldwin and Davenport Hooker to draw resolutions expressing the regret of the Association over the loss of Professor Nussbaum, one of its honorary members.

It was moved and voted that the Association express through its Secretary appreciation of the valuable aid the Wistar Institute is rendering the Association and the progress of anatomy in this country by its very generous and efficient publication of the anatomical journals. And further the Wistar Institute lends greatly to the success of the present meeting by its prompt publication and distribution of the abstracts of the communications to be presented.

On motion the offer of The Wistar Institute to supply all members of the Association, for the dues now paid to the journals, not only all numbers of The American Journal of Anatomy, and the Anatomical Record, but in addition The Journal of Comparative Neurology and the Journal of Morphology, was formally accepted.

THURSDAY, DECEMBER 30. A SHORT BUSINESS SESSION FOLLOWED THE SCIENTIFIC SESSION.

The Committee through its Chairman, Professor Harrison, presented the following resolutions on the death of Professor Nussbaum:

WHEREAS, in the death on November 16, 1915, of Geheimer Medizinalrat Doktor Moritz Nussbaum, Professor of Biology in the University of Bonn, this Association has lost from its roll of Honorary Members a man of keen intellect, profound learning, and broad sympathies, admired and beloved by all who came in contact with him or his work.

Be it therefore resolved, that we, The American Association of Anatomists, express our very deep sense of the loss of an honored coworker, teacher and friend and,

Be it further resolved, that this resolution be placed upon the permanent records of the Association, and that a copy be sent to his family.

(Signed) ROSS G. HARRISON, *Chairman*,
WARREN H. LEWIS,
W. M. BALDWIN,
DAVENPORT HOOKER.

The President then appointed Prof. Florence R. Sabin and Prof. J. P. Schaeffer a committee to formulate resolutions expressing the loss of the Association in the death of Mrs. Susannah Phelps Gage.

The Committee presented the following resolutions:

The American Association of Anatomists, assembled at the Thirty-second Session at New Haven, express profound sorrow at the death of Susannah Phelps Gage. For many years she has been a constant participant at the meetings of the Association and an active contributor to the literature of anatomy.

The members of the Association who came into more personal contact with Mrs. Gage are also mindful of the kind and generous help, advice, and sacrifice of time which she so unstintingly gave.

It is directed that the foregoing Minute be published in the Proceedings of the Thirty-Second Session, and that the Secretary be requested to send a copy to Mrs. Gage's family.

(Signed) Florence R. Sabin,
J. P. Schaeffer.

Before the adjournment of the last session it was voted: That this Association express through the Secretary our thanks and appreciation to Yale University, the Local Committee and to Professors Harrison and Ferris our hosts at this session, for their generous hospitality and the perfect manner in which the Association has been accommodated and entertained.

Charles R. Stockard,

Secretary of the Thirty-Second Session of the American Association of Anatomists.

ABSTRACTS OF PAPERS

PRESENTED AT THE

THIRTY-SECOND SESSION

OF

THE AMERICAN ASSOCIATION OF ANATOMISTS

DECEMBER 28, 29 AND 30, 1915

AT

NEW HAVEN

All papers marked with an asterisk (*) were read by title only

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1. Cell changes in the hypophysis of the albino rat, after gonadectomy. WILLIAM H. F. ADDISON, University of Pennsylvania.

There is a striking alteration in the structure of the distal glandular portion of the hypophysis of the albino rat, following removal of the testes or of the ovaries. These changes are apparent during the second week after gonadectomy, but progress for several months, until the appearance of this portion of the hypophysis is conspicuously altered. The most evident difference is the development of large, vesicular cells, which have the cytoplasm arranged as a peripheral ring, containing in the center a homogeneous colloid-like material.

Alterations in the histological appearance of the hypophysis after removal of the sex gland were first described by Fichera ('05). In Biedl ('13) there is an illustration of the hypophysis of the castrated albino rat, showing, however, only the early changes.

The cells of the distal glandular portion of the hypophysis of the adult albino rat may be grouped in three classes. Already at birth histogenesis has proceeded far enough for these three varieties to be distinguished. In the new-born rat most of the cells are of the primitive undifferentiated type, and from these, here and there, two other cell types (b and c) are seen developing. One (type b) contains distinct granules, which stain more than the other cells with Altmann's acid fuchsin, after neutral formalin zenker fixation (Bensley '11, Am. Journ. Anat.). These are the oxyntic or acidophile cells. The other type of

cell (type c) is distinguished by its larger amount of cytoplasm, which is only finely granular in early life.

At forty-five days of age, the organ has greatly increased in size. The direct descendants of the primitive cells form masses of cells with closely aggregated nuclei and small amount of cytoplasm. These cells (type a) form the principal mass of the cell cords between the blood vessels, and often receive the name of 'chief cells.' The acidophile cells (type b) have greatly increased in number and their granules stain more intensely. The large cells (type c) are also more numerous. These two latter varieties appear to be always on or near the margin of the blood streams.

These three types are believed to be the main varieties of cells found in the adult, the primitive type giving rise to the chief cells and also to the other two kinds. As age progresses the large cells (type c) often develop in their cytoplasm one or more small vacuoles, and, sometimes a denser spot, which is perhaps connected with the secretory activity of the cell, appears in the cytoplasm. As age increases, also, the granules of the cytoplasm of the type c cells are more apparent and tend to stain somewhat more readily with basic dyes.

After castration (e.g., at thirty days of age) changes are seen at the end of one week and at the end of two weeks these changes become clearly apparent. The acidophiles (type b) remain nearly unchanged in number and size, but the large cells (type c) are definitely enlarged and more granular. After the lapse of several months, however, a much more striking alteration is seen. Some of the large cells (type c) are seen to have increased in size, developing a large vacuole or space in which a clear colloid-like substance is present. The small chief cells (type a) appear to be decreased, probably some of their number growing into the large cells (type c). Several stages are apparent in the growth of the large vacuolated cells. 1) Some of the cells retain the nucleus of spherical shape, the cytoplasm granular, and in it a small vacuole and perhaps also a small denser spot. 2) As the vacuole or space, with the colloid-like material becomes larger the nucleus becomes eccentric, the main part of the cell being made up of the colloid-like-containing space. 3) Finally the cells become ring-shaped in section, the cytoplasm forming the periphery of the cell and containing at some point the flattened nucleus. Nearly the entire cell is filled with the colloid-like material. Often the denser spot remains in the peripheral cytoplasm near the nucleus.

In the normal albino rat sometimes small amounts of the colloid-like substance are seen in the vascular channels and in the residual lumen of the pouch of Rathke. In the castrated animals, however, the amount of this substance is increased and it is more often found in the blood vessels and in the persistent lumen.

In female animals the reaction in the cells of the hypophysis after removal of the ovaries follows the same general course as does the reaction in the hypophysis of the castrated male animals.

2. On the fate of the "Ultimobranchial bodies" in the pig. J. A. Badertscher, University of Indiana.*

The considerable amount of work of both a comparative and more specific character that has been done in recent years on the ultimobranchial bodies has led to the interpretation that they do not contribute any structural elements to the mammalian thyroid gland. There is, however, still wanting a detailed histogenetic study through a wide range of developmental stages of well fixed mammalian embryos to give conclusive evidence of the fate of these bodies. The present investigation is concerned with the histogenetic changes that occur in the ultimobranchial elements until they are no longer recognizable in the thyroid gland.

The ultimobranchial bodies in early stages are hollow syncytial structures. Before fusion with the thyroid occurs their lumina become partially obliterated and their walls become partially vacuolar. The thyroid in early stages breaks up into cell cords while in the ultimobranchial bodies this process begins first in 21 to 23 mm. pig embryos or in even later stages. The cell cords when first formed are usually much coarser than those found in the thyroid to which they are fused and apparently are produced in two ways: a) by the invasion of mesenchymal and vascular tissues and b) by the growth of buds from the main stem. The extent to which 'budding' occurs is quite variable in different developmental stages. The posterior part of the ultimobranchial elements usually remains a solid mass longer than their more anterior portion.

The extent to which vacuolation of these bodies occurs varies greatly. In an 18 mm. embryo in which they are not yet fused to the thyroid, the vacuoles are mostly confined to their more central portion. In later stages (up to 125 mm. or thereabouts) after the structure has become partially or entirely broken up into cell cords, the vacuoles are confined mostly to portions of the main 'stem' and to the proximal portion of some of the coarse cell cords attached to it, but not necessarily to the entire structure which, according to recent investigations, is the case in young stages of human embryos.

The structures of the nuclei of the ultimobranchial bodies is uniform up to stages 18 mm. in length and cannot be distinguished from the nuclei of the thyroid gland. In the ultimobranchial bodies of a 19 mm. embryo a few deeply stained nuclei are present. These increase in number and are most numerous in embryos ranging from 21 to 33 mm. in length. In later developmental stages (48 to 125 mm.), in which the ultimobranchial bodies can be distinctly recognized as such, the deeply stained nuclei have almost entirely disappeared. Pyknotic or degenerating nuclei were found in appreciably large numbers in localized areas in the ultimobranchial bodies of 23 and 24 mm. embryo, and in later developmental stages they have almost entirely disappeared. The significance of the deeply stained nuclei is still unknown to me but I am quite certain that they do not represent a general degeneration of the ultimobranchial elements as is held by Simon, Verdun and others.

The nuclei of the ultimobranchial bodies in some stages are quite variable in size but their structure (excepting the darkly stained ones) is the same as of those of the thyroid.

The location of the ultimobranchial bodies in the thyroid is variable. In stages from 19 to 28 mm. in length they are fused to and partially or entirely imbedded in the dorso-lateral margin of the gland. In the later developmental stages examined they may be of greatly unequal length in the same stage, and variable in position in different stages. They may be entirely located in the middle third or two-fourths of the gland or entirely in its caudal half or third. Their usual position in the thyroid is lateral to the median line, more or less deeply imbedded below the dorsal border but may be found imbedded near its lateral border.

In a few stages one or both of the ultimobranchial bodies were found only partially imbedded in the thyroid. Thus, in a 45 mm. embryo their anterior ends remain separated from the thyroid gland. Excepting for a small vacuolar area and traces of the lumen in the left one, both have a structure identical with the thyroid gland. In a 60 mm. embryo the ultimobranchial element on the right side is only partially imbedded in the dorso-lateral border of the posterior third of the thyroid and is represented by coarse and loosely arranged cell cords. In a 125 mm. embryo the right ultimobranchial body is fused to the middle two-fourths of the lateral border of the thyroid but not imbedded in it. It is composed of syncytial masses and of large tortuous cystoid or overgrown follicles which do not contain colloid, although colloid-containing follicles are quite uniformly distributed throughout the thyroid. In a 145 mm. embryo the right ultimobranchial element lies lateral to the medial line of the thyroid along its dorsal surface. Along its entire extent it is partly exposed to the free surface. The portion imbedded in the gland is represented by cell cords in which small follicles containing colloid are quite numerous. These cell cords are identical in structure with those in the thyroid of earlier stages in which colloid is just beginning to form. In the exposed part of this structure are cystoid follicles in which colloid is present. Also, along the right lateral border of the posterior two-thirds of the thyroid in a 245 mm. embryo is an area of many cystoid follicles among which are scattered smaller follicles, all of which contain colloid. This area occupies a similar position to the ultimobranchial bodies in some earlier stages and on account of its many cystoid follicles it apparently represents an ultimobranchial element that was only partially imbedded in the thyroid gland.

In late developmental stages no cystoid follicles were found in entirely imbedded ultimobranchial bodies. In the thyroid, follicles containing colloid appear first in a 75 mm. embryo while in the ultimobranchial elements the colloid-containing follicles appear first in a 145 mm. stage. In a few late developmental stages (including a full term embryo) it was impossible to recognize the ultimobranchial bodies by structural features, but in all (excepting a 175 mm. embryo) areas of small colloid-containing follicles are present. The position of these areas

in the thyroid, in different stages, is variable but they correspond to the variable position of the ultimobranchial bodies in stages in which these bodies can be recognized structurally.

The observations indicate that the now generally accepted view of the fate of the ultimobranchial bodies in all classes of mammals is erroneous. In the pig they apparently contribute to the formation of the structural elements in the thyroid gland.

3. The origin and structure of a fibrous tissue formed in wound healing. (Illustrated and with demonstrations.) GEORGE A. BAITSELL, introduced by R. G. Harrison, Yale University.

In a previous paper (Jour. Exp. Med., vol. 21, pp. 455–479) the author was able to show that in living cultures of adult frog tissues there occurs, in many instances, a transformation of the plasma clot in which the living tissue is imbedded. This transformation results in a consolidation or fusion of the elements of the fibrin net and a consequent formation from it of a fibrous tissue which is identical in its form and structure and in many of its staining reactions with a regular collaginous connective tissue. It appeared evident that, whether or not the fibrous tissue directly formed from the fibrin clot remained as a permanent connective tissue, such a reaction must play an important part in wound healing. The present paper gives the results obtained from an extensive series of experiments undertaken with the purpose of studying the action and fate of the fibrin clot formed during wound healing and they may be briefly summarized as follows:

1. In experimental wounds in frog skin made by removing various sized pieces of skin from the animal there is a rapid coagulation of the blood plasma and lymph to form a coagulation tissue which fills the wound cavity.

2. The observations on living animals show that if the animal remains quiet for a few minutes after an operation the coagulation tissue becomes resistant and is of sufficient strength to hold the cut edges of the wound in place and to retain its position in the wound cavity. The coagulation tissue is also resistant to the action of water and the animal can be placed in an aquarium a few minutes after an operation has been performed without any injury to the coagulation tissue which serves, at least temporarily, as a connective tissue and as a base for the epithelial cells which rapidly move in from all the cut edges to close the wound cavity. Observations have been made on the healing of various types of wounds viz., 1) wounds in which only a cut was made in the skin and no tissue was removed, 2) wounds in which pieces of skin of various sizes were removed and 3) wounds in which pieces of skin were removed and either another piece of skin or the stratum compactum obtained by pancreatin digestion of a piece of adult frog skin were implanted. In all these types of wounds the coagulation tissue formed by the clotting of the lymph or blood plasma was an essential feature of the rapid healing which occurred since it filled the wound cavity and held all the cut edges in their proper positions.

3. The study of prepared sections show that, at first, in the coagulation tissue, formed in the wound as a result of the clotting of the blood and lymph, a typical fibrin net is present. Later this fibrin net is transformed into fibrous tissue containing bundles of wavy fibers in which, in many instances, the individual fibrils can be noted. In the course of a few days the entire clot becomes transformed into this new fibrous tissue. This transformation of the clot and the formation of the fibrous tissue is not due to any intracellular action inasmuch as it take place before the connective tissue cells wander into the coagulation tissue. It is a direct transformation of the fibrin clot and is identical with the process which was previously found (loc. cit.) to take place in the fibrin clots in living cultures of adult frog tissues and which has been noted above. The connective tissue cells which wander into the newly formed fibrous tissue from the cut edges do not digest the fibers but move among them and evidently cause a breaking up of the larger bundles of fibers into smaller ones and later we have formed, as a result, a tissue which is typical in appearance with regular connective tissue. The connective tissue cells are, in many cases, rounded cells when they first appear in the fibrous tissue but later they assume the typical elongated spindle shape of fibroblast cells. This change in shape appears to be due to the action of the cells in stretching along the fibers. The preparations do not show any connection between these spindle shaped cells and the fibers which had already formed, nor is there any evidence of an attempt by them to form new fibers intracellularly.

4. The staining reactions of the new fibrous tissue appear to be identical with the staining reactions of the connective tissue in frog skin. However the newly formed fibrous tissue can be digested in pancreatin and in this reaction it differs from the connective tissue in the skin of the adult frog. On the other hand extensive experiments with pancreatin on embryonic but fully formed connective tissue, obtained from the tail and skin of tadpoles of various ages, show that the pancreatin will digest it just as it does the newly formed fibrous tissue.

5. The experiments do not offer any evidence that the fibrous tissue formed by a direct transformation of the fibrin net is ever replaced by a connective tissue formed by an intracellular action. The newly formed fibrous tissue also appears to be identical in appearance, structure and function with regular collaginous connective tisue. Digestion with pancreatin will differentiate between the new tissue and adult connective tissue from the skin of the frog but this test fails to differentiate between the new tissue and embryonic connective tissue.

4. A standard of measurement in determining the relative size of the heart.
C. R. Bardeen, University of Wisconsin.

The weight of the heart varies with the weight of the body according to the formula:

$$B = ah,$$

where B = weight of the body, h = weight of heart and a is a constant.

According to Vierordt's table based on 590 cases, a equals about 200 for all ages from one month up to 25 years. While other values have been given by various investigators it is probable that this figure is approximately correct when the heart is carefully freed from blood before weighing. There are, of course, individual variations but the average is remarkably constant.

The area of the shadow of the heart, when in parallel light rays perpendicular to the dorsal or ventral surface, varies with the weight of the heart according to the formula:

$$H^{3/2} = xh,$$

where H = the area of the heart shadow; h = weight of the heart and x is a constant, depending on the shape of the heart. While data on a large number of cases are lacking observation on four hearts has shown that the average heart shadow was 81.89, the average weight 0.196 k. so that

$$x = \frac{H^{3/2}}{h} = 3800$$

The area of the X-ray shadow of the heart when studied by means of the orthodiagraph or in radiographs, after making suitable allowance for the divergene of the X-rays, varies with the weight of the body according to the formula:

$$B = \frac{a}{x} H^{3/2}$$

where B = weight of body; H area of heart shadow; a the constant proportion of heart to body weight and x = a constant depending on the shape of the heart.

By a study of a tabulation based on several hundred cases it appeared that the formula $\frac{a}{x} = \frac{1}{20}$ would best fit the observations. This formula agrees fairly well with the values for a and x given above and arrived at by different methods.

If a = 200, then x = 4000
If x = 3800, then a = 190

Plotting a curve according to the formula $B = \frac{1}{20} H^{3/2}$ and analyzing the results shows that the heart shadow of a person weighing 50 k. (110 lbs.) should be 100 sq. cm., and that of a child weighing 20 k. (45 lbs.) should be about 55 sq. cm., therefore for weights below 50 k. subtract $1\frac{1}{2}$ sq. cm. for each kilo ($2\frac{1}{5}$ lbs.) At 10 k. the size of the heart shadow according to this curve should be 35 sq. cm. Therefore for each kilo below 20 k. (heart area 55 sq. cm.), down to 10 k. subtract 2 sq. cm. At 66 k. the area of the shadow is approximately 120 sq. cm. Therefore for weights between 50 k. (110 lbs.) and 66 k. (145 lbs.) add 1.25 sq. cm. for each kilo ($2\frac{1}{5}$ lbs.) For weights above 66 k. add 1.1 sq. cm. for each kilo. At 120 k. (265 lbs.) the area of the heart shadow according to this curve should be 180 sq. cm.

To test out the value of this curve for which together with other mathematical aid, I am indebted to my colleague, Prof. Max Mason, I have retabulated such available trustworthy data as have been at hand. First Dietlens 261 cases (74 women, 187 men), used in his valuable orthodiagraphic studies of the normal heart, second 123 of Schieffers 125 cases used in his orthodiagraphic studies of the effects of severe muscular work on the heart and third 61 cases of my own studied by the teloradiographic methods (4 children, 38 normal adults, and 19 healthy athletic students), in all 445 cases. These cases have been plotted individually, then tabulated in averages for each kilogram of weight and finally averaged for each ten kilograms for the sake of simplifying the plotting of the curves.

The curves plotted from the combined data follows closely the theoretical curve from 18 k. (39 lbs.), 50 sq. cm. up to 45 k. (99 lbs.), 94 sq. cm. From here it diverges slightly toward proportionately larger areas than called for by a given weight up to 75 k. (165 lbs.) 136 sq. cm. At this point the average heart area is 5 sq. cm. larger than called for by the theoretical curve 131 sq. cm. Beyond this point the curve diverges in the opposite direction so that at 83 k. (183 lbs.) the average area (132.4 sq. cm.) is $7\frac{1}{2}$ cm. smaller than called for by the theoretical curve (140 sq. cm.). At 94 k. (207 lbs.) the average area is 145 sq. cm., seven less than called for by the theoretical curve (152 sq. cm.).

The divergence of the curve toward the larger areas for weights between 45 k. and 75 k. is undoubtedly due to the inclusion of the relatively large number of Schieffer's cases which were selected to study the effects of hard muscular exercise on the heart and were shown by Schieffer to prove that the hearts of those engaged in physically severe occupations or took part in hard bicycle riding are larger than the hearts of average individuals. This is shown by the fact that the curve based on averages of Dietlen's 187 normal men varies not more than the distance which represents a square centimeter from the theoretical curve from 45 k. up to 75 k. Beyond here the curve diverges like the general curve sharply toward a smaller size than called for by the theoretical curve. The average of Dietlen's four cases weighing 80 k. or more is 128 sq. cm. while the theoretical curve calls for 141 sq. cm. for the same average weight.

This divergence is also shown slightly less marked in the averages of my own cases of normal men, the curve of which corresponds closely to the theoretical curve up to 75 k. In case of athletes and of those who follow severe occupations the hearts of individuals of average weight are as a rule considerably larger than called for in the theoretical curve but in such individuals above 75 k. (165 lbs.) in weight the size of the heart shadow approaches closely to that called for by the normal curve. This divergence from an average area much greater than the theoretical normal approximately to the theoretical normal is shown in Schieffer's cases and in the athletes studied by me. The relatively smaller hearts thus found in heavy individuals can best be accounted for, I believe, by the facts that as a rule individuals who approach 85 k. (187 lbs.)

or more in weight have relatively more fat and less muscle than those of lighter weight and that the size of the heart is strictly speaking determined rather by the development of the skeletal musculature than by mere body weight, although the latter alone is subject to direct measurement.

This probably also accounts for the fact pointed out by Dietlen that tall individuals of a given weight are apt to have larger hearts than shorter individuals of the same weight. I have not attempted to plot a curve from this point of view but the curve showing the average area of the heart shadow for women probably illustrates the same thing. A woman weighing 50 k. (110 lbs.) as a rule is shorter and fatter than a man of the same weight. The average size of the heart shadow of women averaging 45 k. (99 lbs.) coincides with the theoretical size called for by the curve (92 cm.). But the average heart shadow area of women averaging 55 k. (121 lbs.) in weight is 7 sq. cm. below that called for by the theoretical curve (about 100 instead of 107 sq. cm.) and for those averaging 63 k. (138 lbs.) in weight the divergence is still greater (106 sq. cm. instead of 115.5 sq. cm.).

While we have as yet insufficient data thoroughly to test out the curve, especially for individuals below 40 k. (88 lbs.) and above 75 k. (165 lbs.) in weight it gives promise of furnishing a useful standard with which to compare the heart shadow of an individual of a given weight and thus to determine whether or not his heart is of normal size and if not to what extend it deviates from the normal. In carrying out such a study many factors must be taken into account beside those mentioned, such for instance as the shape of the chest, but certainly far more accuracy is now possible than in the standard clinical method of guessing at the amount of cardiac hypertrophy from the relation of the "apex beat" to the nipple line.

5. The development of the hypophysis in turtles. E. A. Baumgartner, Department of Anatomy, Washington University Medical School.

In the present work embryos of Chrysemys marginata and Aromochelys odorata were used as the basis of the material for observations on the development of the hypophysis. Chrysemys picta and Pseudemys elegans were the forms chosen for the study of the adult hypophysis.

The first definite outpouching of the hypophysis as observed in 3 mm. embryos consists of a single median evagination of the epithelium of the roof of the mouth. This outpouching is similar in form to that described for other vertebrates and constitutes the so-called Rathke's pouch. In a 5 mm. embryo two additional phases in the development of the hypophysis become evident—the formation of two lateral buds from Rathke's pouch and a thickening of the epithelium anterior to the pouch. These two anlagen, together with the median pouch, constitute three primary structures participating in the formation of the adult organ.

Embryos of 7 mm. Of the three structures, the epithelial thickening has undergone a marked evagination including the roof of the mouth and the base of Rathke's pouch; it is the beginning of the anterior

lobe of the adult. This, together with Rathke's pouch and the lateral buds is partially constricted from the roof in such a manner that a hypophysial stalk can now be described joining the floor of the anterior lobe and the roof of the mouth Rathke's pouch and the lateral buds now open in common into the caudo-superior part of the anterior lobe. In larger embryos the free ends of the lateral buds extend forward and dorsally and the area of their attachments extends forward with the cranio-caudal development of the anterior lobe.

Embryos of 17 mm. The long diameter of the hypophysis is cephalo-caudal. Of the lateral buds, the distal parts present a wing-like form and extend forward beneath the brain floor; the proximal parts, lateral to the anterior lobe being crescentic in section. The caudo-dorsal tip of Rathke's pouch has developed into a flattened mass, the superior lobe. This structure is closely applied to the floor of the infundibulum.

In larger embryos many cord-like growths develop on the surface of the superior lobe. In newborn the lateral lobes show two changes; the wing-like parts are united across the median line forming a layer which is closely attached to the floor of the diencephalon cephalad to the infundibulum; the crescentic proximal parts are united by outgrowths of their free edges both dorsally and ventrally around the anterior lobe, so that the latter is partly enveloped by the layer so formed. Dorsad to the anterior lobe these two layers are connected by a small stalk.

Adults.—The hypophysis appears as a large ovoid organ ventral to the brain. In sections the parts described above are readily seen. The proximal parts of the early lateral lobes completely surround the middle portion of the anterior lobe in the form of a layer. This is composed of cells arranged in cords which are continuous with similar structures of the anterior lobe. The distal portion of the lateral lobes, underlying the brain floor, is also arranged in cords which have been invaded by a considerable amount of connective tissue. The anterior lobe consists of cords and short tubules continuous laterally with the cords of the surrounding lateral lobes. The superior lobe, made up of layers of cells surrounds the ventral, lateral and caudal walls of all the branches of the infundibulum and is in contact ventrally with the anterior lobe. The cords and tubules of the anterior lobe are composed of polyhedral cells, some granular and acidophilic, others clear and much darker staining. Occasional colloid-like secretions are found in the tubules. The cells of the lateral lobes are small, non-granular polyhedrals, staining darkly. The layers of the superior lobe are composed of tall, columnar, non-granular cells which take eosin lightly.

Summary. The caudo-dorsal tip of Rathke's pouch develops into the superior lobe of the adult hypophysis. The remainder of Rathke's pouch and a later anterior evagination form the anterior lobe. The lateral buds develop into a thin layer underlying the floor of the diencephalon and a narrow layer surrounding and forming part of the adult anterior lobe. Three parts differing histologically can be distinguished in the adult hypophysis.

6. Notes on the alimentary canal of the hyper-ontomorph and the Meso-ontomorph. ROBERT BENNETT BEAN, Tulane University of Louisiana.

Epitheliopath or Hyper-ontomorph	*Mesotheliopath or Meso-ontomorph*
Stomach small	Stomach large
Stomach low	Stomach high
Stomach J shaped	Stomach oval
Stomach vertical	Stomach diagonal or transverse
Stomach far to left	Stomach more to right
Liver small	Liver large
Liver low	Liver high
Liver vertical	Liver transverse or diagonal
Liver far to right	Liver more to left
Small intestine small	Small intestine large
Small intestine short	Small intestine long
Length 15 to 20 ft. or less	Length 20 to 25 ft. or more
Colon long	Colon relatively short
Colon, low hepatic flexure	Colon, high hepatic flexure
Colon, high splenic flexure	Colon, low splenic flexure
Colon, transverse, long low loop	Colon, transverse, short high loop

The position of the viscera may account in part for the susceptibility of the Hyper-ontomorph to tuberculosis, insanity, pellagra, leprosy, and carcinoma, and the comparative immunity of the Meso-ontomorph to these diseases. The five diseases mentioned seem to be diseases due in some measure, probably primarily, to faulty nutrition.

Data: 1002 patients in hospitals, 317 post-mortem examinations.

7. The origin of the posterior portion of the vena cava inferior in the white rat. (Lantern.) ALEXANDER S. BEGG, Harvard Medical School.

The changes in the posterior cardinal system of veins in the white rat can be readily made out, since in this animal the Wolffian bodies are quite small and certain of the complications met in other mammals are not present. The relation of the developing kidneys to the posterior cardinal veins is unmistakable. The kidney lies at first ventral and later lateral to the corresponding vein, so that at no time does the vein cross the path of its migration. Consequently a peri-ureteric loop is never formed. Moreover, below the diaphragm there is no supracardinal system of veins. The right subcardinal vein anastomoses with the hepatic sinusoids and establishes the vena cava. Below the entrance of the renal veins, the vena cava of the rat is the persistent right posterior cardinal vein. The left posterior cardinal disappears through most of its extent. The lumbar veins drain first into the cardinals and later into the vena cava. In the thorax, there is apparently a supracardinal system which gives rise to the azygos veins. Owing to the relatively slight development of the Wolffian bodies in the rat, its venous system may be much simpler than that in other mammals, notably

than in the pig, where these organs are very large. It is therefore questionable whether conclusions drawn from either the pig or the rat are of general application, but the conditions in the rat, as here described, may readily be demonstrated.

8. Endocranial markings of the human occipital bone and their relations to the adjacent parts of the brain, with special reference to the so-called 'vermiform fossa.' DAVIDSON BLACK, From the Anatomical Laboratory, School of Medicine, Western Reserve University.

The study upon which these observations are based began as an investigation into the relations between the human cerebellum and the occipital bone in the presence on the latter of the so-called 'vermiform fossa.' Since October, 1914, I have encountered this anomaly in the dissecting room four times (among some sixty odd subjects examined) and have been able to prepare endocranial, endodural and encephalic casts in each case. In making these casts, I have followed the method used by Symington in his researches upon cranio-cerebral topography (vide: Edinburgh Med. Jour., Feb., 1915).

In the course of this work a striking difference was noted in the character of the variations of the endocranial markings on the squama occipitalis below the sulcus transversus as compared with those of the superior fossa above this line.

In any enquiry into the significance of such differences in the endocranial relations of adjacent parts of the same bone to the underlying portions of the brain, the phylogenetic relations of the cerebrum and cerebellum to the skull must be taken into consideration.

Endocranial surface of fossa occipitalis superior. Elliot Smith, Le Double and others have called special attention to the peculiar asymmetry of the endocranial markings of this region of the occipital bone and to the definite influence of the occipital poles of the cerebrum upon these markings. My own series of casts amply bears out the observations of these authors and furnishes additional evidence of the great variability of the endocranial pattern in this region. Though it is evident that a close correspondence obtains between such juga cerebralia and impressiones digitatae as are present and the fissural pattern of the occipital poles of the cerebrum, yet it should also be noted that all the details of cerebral pattern in this region are not recorded in every case by endocranial markings. The significance of this point will be discussed in a subsequent communication. In the present connection the interest in these observations lies in the fact that they demonstrate once more that the markings on the lateral areas of the endocranial surface of the superior occipital fossa are intimately associated with corresponding irregularities on the surface of the caudal poles of the cerebrum.

Such a close association, however, does not obtain between the cerebellum and all adjacent parts of the occipital bone, for the volume of the posterior skull fossa may be appreciably increased by the presence of a well marked 'vermiform fossa,' throughout the greater part of which no portion of the cerebellum comes in contact with the dura.

Thus cerebellar growth can not be the direct causal factor in the production of this anomaly.

The relation of the convex surface of the cerebrum to the endodural and endocranial surfaces, except perhaps in the neighborhood of the superior sagittal sinus, is everywhere an intimate one. Small or large subarachnoid clefts (flumina) are of course present where the cerebral arachnoid bridges across the various fissures, but it is just such locations, analogous to the cisterna magna, that favor the development of endocranial ridges however slight. These ridges, while they are poorly developed in man and seldom extend deeply in the intergyral spaces, furnish by their presence direct evidence of the action of endocranial growth phenomena of an entirely opposite variety to those causing the formation of an anomalous endocranial fossa overlying the cisterna magna.

Endocranial surface of fossa occipitalis inferior—Vermiform fossa. The following series of lantern slides showing endocranial, endodural and encephalic casts of both the normal and anomalous human occipital region is sufficient to demonstrate conclusively that the so-called 'vermiform fossa' occurs absolutely independently of the inferior vermis. When the fossa is present, a part of it may lodge a small area of the tonsils and biventral lobules of the lateral cerebellar lobes. For the most part, however, it represents a great enlargement of the space between the dura and the brain and thus probably of the cisterna magna. I have been unable to demonstrate any considerable enlargement of the cisterna magna in the cases here recorded, but that may readily be due to injury to the arachnoid during removal of the brain. After removal the relation of the arachnoid bridging the cisterna cerebello-medullaris differed in no discernible way in these specimens from that normally obtaining in this region.

A median cerebellar fossa as a normal and characteristic feature occurs among anthropoids only in Hylobates. At the same time in this form alone of the Simiidae is the fossa excavated for the lodgement of a definite part of the so-called vermis cerebelli.

In contrast to the condition obtaining in the large anthropoids and man, the median cerebellar fossa is a characteristic feature of the occipital bone elsewhere among the mammalia, and it is excavated in these forms for the lodgement of a median cerebellar protuberance. This fossa is well developed in insectivores, bats and all rodents and carnivores. It is present in the Sirenia and Cetacea and also in most ungulates, edentates and marsupials. In Echidna it is a well marked feature; and, as in Ornithorhynchus, there is a hiatus in the occipital bone over most of the area corresponding to this region.

Endocranial surface of fossa occipitalis inferior—Lateral areas. Unlike the inferior-vermis, the great lateral lobes of the human cerebellum lie in contact with the dura of the occipital bone. This contact extends over the lateral areas of the inferior occipital fossa. An indication of intimate association between the lateral cerebellar lobes and the bony wall of this region is seen in the presence of a poorly defined but fairly

constant ridge on each lateral portion of the inferior occipital fossa. This ridge conforms in the recent state to a part of the great horizontal fissure of the cerebellum. Other depressions and ridges may occur in this region, but these are both variable and inconstant and may be due either to direct cerebellar influence or to that of irregular vascular channels.

Mention may here be made of the *trigonum vermianum* of Schwalbe, but only to point out that the term is a misnomer and the area to which it is applied has a variable relation to the tonsils and a part of the biventral lobules of the lateral cerebellar lobes and never to the vermis. The relations of parts of the lateral cerebellar lobes to the walls of the posterior skull fossa are subject to much variation. This is evident when it is noted that in not a few cases a portion of both tonsils and biventral lobules may project into the foramen magnum. (Vide: Foriep, Anat. Anz., Bd. 19, 1901; Schwalbe, Verhand. d. Anat. Gesellschaft, Apr., 1902).

The arrangement of the sagittal and transverse sulci and internal occipital protuberance requires no description in this connection.

The occurrence of the median cerebellar fossa in the human occipital bone has been credited both to the presence and to the absence of the ossicle of Kerkring. The fallacy of such arguments, however, has been pointed out by Le Double, who has shown that the ossicle of Kerkring is inconstant in its presence both in carnivores and in rodents, though the fossa in question is constantly present in these forms.

Both Le Double and Poirier et Charpy state that this fossa in man is probably an atavism, but these authors lay no stress upon the important changes in endocranial relations that permit the expression of such a phenomenon in this region

Throughout the mammalian series, neopallial expansion and cerebellar growth have been the dominant factors in causing increased skull capacity. In most of the lower gyrencephalous mammalia the superficial convolutional pattern over the convex surface of the cerebrum is accurately recorded by endocranial ridges. These ridges, as I have pointed out above, are in themselves direct evidence of cerebral influence upon endocranial growth whether they accurately conform to the details of cerebral pattern or not.

The areas of the cerebellum in contact with the endocranial surface of the skull in the lower mammalia comprise the floccular lobes and, broadly speaking, that part of the great interfloccular mass lying behind the fissura prima. The postero-median lobe of Bolk varies greatly in its development in different mammals, but in all forms below the large anthropoids and man, it is more or less closely related to the skull. By this cerebellar contact the bone is excavated to form the middle cerebellar fossa.

The great development of the anso-paramedian lobe of Bolk in man and to a lesser degree in the gorilla, chimpanzee and orang, has caused the postero-median lobe of the cerebellum to become completely separated by a deep cistern from the endocranial surface of the occipital bone.

In this cistern between the lateral cerebellar lobes there is usually situated a small phylogenetically recent fold of dura (falx cerebelli), whose endocranial attachment is marked by the internal occipital crest.

Thus there is a small median area of the endocranial surface of the occipital bone between the lateral areas of the inferior fossa, in man and the great anthropoids, which is no longer subject to the direct and positive influence of a postero-median cerebellar lobe. In about 4 per cent of human skulls (Le Double) there appears in this region a fossa which is independent of direct cerebellar influence but resembles in all other essential respects the similarly situated median cerebellar fossa characteristically developed in all the lower mammalian familes. The so-called 'vermiform fossa' in man and the great anthropoids may thus be considered to be the result of the action of certain atavistic forces (the mneme of Henri Bergson) which have not yet been completely overcome or neutralized by phylogenetically recent changes in the endocranial relations of the cerebellum.

9. A topographical study of the 13 mm. chick embryo. EDWARD A. BOYDEN, Harvard Medical School.*

This work has been undertaken as a contribution to the comparative embryology of birds and mammals. The body of the account is a description of the gross anatomy of a chick embryo of five days' incubation (13 mm. length), based on reconstructions designed to duplicate those made by F. T. Lewis in his account of the 12 mm. pig, but supplemented by gross dissections, reconstructions of older and younger stages, wax models and India-ink injections. That portion of the work now presented deals with the comparative study of reconstructions showing the 13 mm. chick and 12 mm. pig in mid-sagittal section; with dissections of the body cavities of the two embryos in which the more striking differences in the arrangement of the abdominal viscera are exhibited; and with reconstructions of the brain and cerebral nerves of the two embryos. In conclusion, special attention has been given to the interesting relations of the upper spinal, and occipital nerve roots in the hypoglossal complex, the details of which will be described in a later paper.

10. The interrelations of the mesonephros, kidney, and placenta in different classes of animals. J. L. BREMER, Harvard Medical School.*

The status of the mesonephros as an excretory organ is questioned by Felix, in the Keibel-Mall Embryology, and by Weber, both of whom find that in man and many other mammals the organ degenerates before the kidney can possibly be considered functional, and that thus no continuity of embryonic excretion is apparently provided for. Rather than accept the idea of this discontinuity, they prefer to consider that excretion is not necessary until the kidney is developed, and assign to the mesonephros perhaps some unknown function, but certainly not that of excretion. Weber was strengthened in this opinion by the condition found in the mouse and rat, in which animals the mesonephros is always

rudimentary, and in the mole, in which the organ is small and degenerates very early. He was puzzled by the fact that in the pig the mesonephros persists in full functional activity until late fetal life, when the kidney is apparently fully active, but thought that this single case where continuous fetal excretion was possible, but not proved, should not vitiate his opinion gained from so many other animals.

That some other fetal organ might supply the needed excretory function when neither mesonephros nor kidney is capable of activity does not seem to have been considered by these authors, nor have they thought of the possibility of differences in the various classes of animals as to whether or to what extent this other organ of excretion should be called on. Yet physiologists have for some time been familiar with the fact that certain substances may pass from fetus to mother by placental exchange, and were only at a loss to understand why this was not found to be true in certain classes of animals, as well as in others.

Taking as a standard sign of the possibility of urinary excretion the arrangement of a thin epithelial plate overlying and in close contact with a fetal capillary, such as one finds in the glomeruli of mesonephros or kidney, I have examined the placentae of different classes of mammals, at various ages, and compared the results with the conditions of the mesonephros and kidney in corresponding embryos and fetuses. The following conclusions have been reached.

The Wolffian body or mesonephros is a gland of urinary excretion.

Mammalian embryos may be divided into two classes; those which retain functional Wolffian bodies until the kidneys are sufficiently developed to excrete urine, as is the case in birds and reptiles, and those in which the Wolffian bodies degenerate before the kidneys reach functional ability. The first class includes the pig, sheep, and cat, the second, the rabbit, guinea pig, man, and rat.

Within reach of these classes individual animals show great differences in the size and presumable excretory ability of the Wolffian bodies, without regard to the length of their duration.

The allantois is the receptacle of the urine formed within the body of the embryo; it is present as a reservoir only in those animals with an embryonic excretion, and its size varies with the size of the Wolffian bodies and with their duration. The urethral opening, though present, is not normally used for the passage of fetal urine.

In those animals without the possibility of a continuous urinary excretion within the embryo, i.e., with an early degeneration of the Wolffian body, the placenta is provided with an apparatus similar to that found in the glomeruli of the Wolffian body or the kidney, thin plates of epithelium overlaying the fetal capillaries. These appear in the placenta at about the time when the Wolffian body commences to degenerate, or in the case of the rat, which never develops mesonephric glomeruli, at about the time of the normal development of the glomeruli in other embryos. These plates continue and increase in number till term. They are apparently of greater extent in animals whose embryos are provided with large Wolffian bodies.

In the placentae of those animals with a continuous embryonic urinary excretion, similar plates are not found, whether the placentae be of the apposed or conjoined type.

From these facts it appears that embryonic and fetal urinary excretion takes place wholly through the placenta in the rat, at first through the Wolffian body and later through the placenta in the rabbit, guinea pig, and man, but never through the placenta in the pig, sheep, or cat. A knowledge of these differences should lead to more intelligent experiment on the permeability of the placenta.

11. The development of the vertebral column in the domestic cat, from the membranous to the completion of the cartilaginous stage. ALFRED J. BROWN, The Anatomical Laboratory, Columbia University.

The study of the development of the vertebral column prior to the stage at which completely cartilaginous vertebrae are present affords a basis for the analysis of the mammalian vertebra into elements, which on the one hand can be homologized with the separate osseous elements of certain extinct reptiles, and on the other may assist in the interpretation of some of the anomalies of the adult spine.

The first differentiation of the mesenchyme about the chorda is initiated by the appearance of condensations in the form of flattened plates which are situated opposite the intermyotomic intervals. They are obliquely placed and inclined caudo-ventrad. Laterad they extend to the mesial border of the myotomes and are pierced at their centres by the notochord. These plates of thickened mesenchyme have paired dorsolateral and ventrolateral extensions which lie in the intermyotomic intervals, the former between the dorsal margins of the myotomes, the latter between the ventral. Between the bases of the two processes on each side the membrana reuniens is but feebly developed. The whole complex corresponds to the "primitive wirbelbogen" of Froriep. The central portion of this condensation will form the intervertebral disc while the dorso and ventrolateral projections mark the site of development of the future neural arches and costal processes respectively. The condensation develops a vertical ridge on its cephalic and caudal surfaces which tends to divide the compartment between each pair of platelike septa (site of future centrum) into lateral compartments, which in turn are divided into a pair of cephalo-dorsal compartments and a pair of caudo-ventral compartments by the notochord. The cephalo-dorsal arms of the condensation enlarge cephalad and the caudo-ventral arms do the same, the latter becoming bifurcated at their extremities, one arm of the bifurcation passing ventral to the interprovertebral artery and the other dorsal to the same.

In the above process the main portions of the vertebra are laid down. The undifferentiated mesenchyme between the condensations will form the major portion of the centrum. The dorsal arms are the basidorsals and become the neural arch. The central portion of the condensation becomes the intervertebral disc and the ventral arms are the basiventrals which eventually will be divided into the costal element or basiventral proper and the intercentral element.

Chondrification. Begins first on the caudal surface of the basi-dorsals. Following this four centers are found, two on each side of the ventro-dorsal partition arranged as follows: the dorsal pair occupy a cephalic position dorsal to the notochord and the ventral a caudal position ventral to the notochord. Each lateral pair fuses rapidly forming a ventro-dorsal bar of cartilage. These fuse ventral and dorsal to the chorda thus forming a ring around that structure. In the early stage this ring shows bifurcation cephalo-dorsally and caudo-ventrally thus still indicating its original quadrupartite character. These structures are homologous to the interdorsals and interventrals of reptiles.

The basidorsal loses its connection with the intervertebral disc and become attached to the cephalic portion of the corresponding inter-dorsal, thus exhibiting a caudal shift.

The common basiventral and intercentral is still membranous. It breaks away from the intervertebral disc at the junction of its mesial limit with the disc. It also exhibits a caudal shift and still membranous lies between the caudo-lateral surface of the interventral and the cephalo-lateral surface of the intervertebral disc, filling up the interval between the caudal surface of the growing cartilage and the intervertebral disc. Chondrification begins in this membrane at two points, one adjacent to the interventral and one in the intermyotomic interval, lateral to the first. The center adjacent to the interventral fuses quickly with the caudo-lateral portion of the latter and chondrification proceeds caudal gradually filling up the membranous wedge between interventral and intervertebral disc. This portion of the basiventral corresponds to the intercentral of the reptile. The portion chondrifying in the intermyotomic interval represents the costal ele ment of the cervical vertebrae and the true rib of the thoracic segment of the column.

The elements present in the form of individual cartilaginous or membranous units at various stages of development are:

Two basidorsals = Neural arch.

Two interdorsals, Two interventrals, two intercentrals = Centrum.

Two basiventrals = two intercentrals, two costal processes.

The above units fuse with each other except for the costal processes in the thoracic region of the spine which persist as separate elements through the development of joints between the capitular portion and the centrum on the one hand and the tubercular portion and the neural arch on the other.

12. The regeneration of the forebrain of Amblystoma. H. Saxton Burr, Anatomical Laboratory of the School of Medicine, Yale University. (Introduced by H. B. Ferris).

The following is a report of one of a number of experiments on the regeneration of the brain of Amblystoma. Two series of operations were performed on Amblystoma larvae possessing neither peripheral

nerves nor a circulatory system. In the first of these the right nasal placode and the right telencephalon were completely extirpated. In the second, the right cerebral hemisphere was removed but the right olfactory anlage was returned to its original position.

The results of the first operations were definite. No regeneration of nervous tissue occurred. The ependymal cells surrounding the interventricular foramen, left open by the operation, formed a thin curtain completely closing it. These ependymal cells are under certain conditions potential neuroblasts, into which they will develop upon stimulation from the proper source, in this particular instance the nasal placode. The removal of the olfactory anlage precludes any stimulus, chemical or otherwise, being derived from the mere presence of the placode and in addition prevents the stimulus normally found in the ingrowth of the olfactory nerve. It is not surprising, then, that no regeneration occurred.

The operations of the second series were interesting because here the layer of ependymal cells closing the foramen of Monroe was subjected to the stimulus of the ingrowing olfactory nerve fibers, and later to the stimulus of the functioning olfactory organ, since the nasal placode was returned to its proper position after the removal of the underlying telencephalon. The result was the regeneration from the ependyma of a new hemisphere which in one case, the oldest larva of the series, was complete.

Regeneration of the telencephalon in Amblystoma, then, occurs whenever connection between it and the functional end organ is not prevented.

13. The functional relation of intercellular substances in the body to certain structures in the egg cell and unicellular organisms. MONTROSE T. BURROWS, Department of Pathology, Johns Hopkins University.

In an article presented last year before this society the author introduced facts to show that whether an embryonic heart muscle cell in a tissue culture grows and divides, grows to form a syncytium, differentiates, contracts rhythmically, or remains inactive depends upon the particular kind of environment into which it is placed. Many of the peculiarities of the environment peculiar to each form of activity were described at that time and evidence was presented to show that these various activities are not the result of an organization contained within the cell but that they are the result of differential changes of the surface tension of these elements. Each form of work and the structure peculiar to each form of work is the result of a specific kind of change. The changes in the surface tension are brought about and maintained by an organization in the environment, external to the cell but influenced by the cell as any phase of any physical chemical system of this kind influence other phases.

These experiments indicate that the cells of the body differ from egg cells and many unicellular organisms in that they do not possess the total organization necessary for their activity but depend for parts

upon structures external to them. In the light of this fact it became of interest to compare the structure of the egg with the structure of the organization peculiar for the growth and the mitotic division of the body cells. It seemed evident that by this method one could determine definitely the true significance of many of the structures peculiar to these cells. What could be applied for the study of the egg cell could be applied also for the study of many unicellular organisms.

In the present article the author wishes to point out certain analogies between the organization of the environment suitable for the growth of the body cells in the culture and certain structures peculiar to the egg and unicellular organisms as well as the relation between this organization peculiar for the growth of the cells in the culture and the organization peculiar to growing parts of the developing and the mature individual.

14. Microdissection studies on cell structures. Robert Chambers, Jr., Cornell Medical College, New York City.

(Demonstration of a double Barber pipette holder for the use of two needles and of a substage condenser which produces excellent definition for oil immersion work at a working focal distance of almost one centimeter.)

The limitations of the microdissection method owing to the injurious effects of puncturing with the needle must be realized and false interpretations are to be guarded against. One must also take into account the effect of surface tension phenomena of the dissection medium which is used as a hanging drop and, of course, the suitability of the medium in preserving normal conditions. The injurious effects of heat are eliminated by the use of a water filter and the various layers of glass through which the light must pass before reaching the object frees the light of its injurious rays.

Injurious effects of the needle. Tearing of the cell is very generally followed by a swelling with the absorption of water and a change in the chemical reaction of the protoplasm. The cell nucleus is also almost instantly affected by the touch of the needle, a granular precipitate being followed by a condensation of nuclear material into a viscous, highly refractive, gelatinous and amorphous mass.

Experimental data. 1) A morphologically differentiated film or membrane on the surface of the cell has been demonstrated only in free living cells, e.g., eggs, Protozoa. 2) The physical consistency of protoplasm may be summarized as follows—an optically homogeneous, gelatinous substance differing markedly in consistency in different cells and at different times. On extensive tearing or by quick and rapidly repeated thrusts of the needle the protoplasm turns acid in reaction, swells and goes into solution; or becomes vacuolated and granular and coagulates. Normal conditions, however, are apparently maintained if the needle be carefully manipulated and in this way the structure of the cytoplasm of orthopteran germ cells, sea urchin eggs and various somatic cells has been studied. 3) The physical consist-

ency of morphologically differentiated cytoplasmic structures has been studied. 4) The production of a chromatic network and of chromosomes in the hyaline substance of the nucleus has been studied, also the consistency of the spindle-shaped nuclear mass in dividing cells. 5) Localized surface changes in dividing cells were produced by the needle and by various solutions. 6) Localized differences in response to stimuli have been noted in the cytoplasm of certain cells. 7) Transmission in protoplasm of the effects of mechanical stimuli has been noted.

15. A study of the reaction of mesenchyme cells in the tadpole's tail toward injected oil globules. ELIOT R. CLARK, University of Missouri.*

In their later studies on the mode of development of lymphatics, Huntington and McClure have repeatedly reiterated the view that lymphatics are formed by the transformation of mesenchyme cells, in the following manner. They hold that fluid accumulates in the tissue spaces, forming small lakelets; that the mesenchyme cells are pressed upon by the fluid collected, and that as a result of the mechanical pressure supposed to be exerted, the mesenchyme cells react by flattening out and forming membranes around the lakelets. Innumerable isolated blisters formed in this manner are held to be the beginnings of the lymphatic endothelium, vessels being formed by the coalescence of neighboring blisters.

The evidence for this view consists almost entirely in the interpretation of certain appearances, seen in cross sections of embryos, which are in many cases open to other interpretations. No facts have been presented which prove conclusively that, if fluid accumulates in the tissue spaces, the mesenchyme cells, pressed upon by such accumulations will form endothelial membranes, and that membranes so formed will become lymphatic endothelium.

The present investigation was undertaken in order to study, in the living, the reaction of the mesenchyme cells to the pressure of globules of fluid artificially introduced into the tissue spaces, to see whether they react by the formation of membranes, and, in case they do, to study the property of such membranes, particularly their reaction toward blood-vessels and lymphatics.

The studies consisted in the introduction into the transparent fin expansion of the tail of Bull-frog and Fowler's toad larvae, at early stages, of minute globules of paraffin oil, and of watching, in the living larvae, the reaction of the individual mesenchyme cells, blood, and lymphatic capillaries in the neighborhood of the injected globules.

It was found, considerably to our surprise, that the mesenchyme cells showed no sign whatever, of even a tendency to flatten out and form membranes around the globules. Instead, they maintained their identity as branched mesenchyme cells, with their property of slow progression, by the sending out of processes on the one side, and retraction on the other. This was true even of mesenchyme cells against which the injected globules were forced by the injection, as well as those against which the globules pressed, as a result of a slight shifting of

position of the globule, which occasionally occurred. Obviously, since the mesenchyme cells failed to form membranes around the globules, it was impossible to study the reaction of blood and lymph vessels to such membranes. Toward the oil globules themselves, however, the blood and lymph capillaries remained quite indifferent—apparently entirely unaffected by their presence.

The only observable reaction on the part of the living cells to the injected globules consisted in a more or less intense leucocytosis, which usually subsided in the course of a few days, and which was probably caused by slight grades of infection. In some cases there was almost no leucocytosis. In several instances leucocytes were watched as they moved to the oil globule, flattened out on its surface, and moved away again. It is possible that, if sections were made at the time when leucocytes were flattened out against the globules, one might interpret them as flattened endothelial cells.

It thus appears that the notion that mesenchyme cells are stimulated by the mechanical pressure of globules of fluid to flatten out and form membranes, and that these membranes are the beginnings of lymphatic endothelium, fails to stand the test of experiment, and of direct observation on the living animal.

16. The loose connective tissue, as seat of lympho-granulopoesis. Wera Danchakoff, Rockefeller Institute, New York City. (Introduced by W. H. Lewis.)

The loose connective tissue of an adult hen includes beside the fibroblasts many kinds of amoeboid cells and small nodes of true lymphadenoid tissue.

1) The amoeboid cells of the connective tissue are the product of the differentiation of the mesenchymal syncytium in the nodes. After destruction of the lymphoid tissue by X-rays the regeneration of the lymphatic cells takes place at the expense of the mesenchymal syncytium in the nodes.

2) The mesenchymal anlage of the amoeboid cells in the connective tissue and the mesenchymal anlage of the other haematopoetic organs are identical. One may interchange the different lines of the differentiation of the mesenchyme. The same mesenchyme, which for example normally forms merely thin connective tissue septa between the muscle bundles, is capable of differentiating into haemoblastic and leucoblastic tissue. This occurs in the embryonic mesenchyme of a chick after grafts of an adult chick embryo. These changes of the mesenchyme being ubiquitous, we have to conclude that the loose mesenchyme of a chick embryo (6 to 10 days) is equivalent in all the regions of its localisation and is polyvalent in its potencies of development.

The once differentiated cells are not capable of interchanging, but the various lines of differentiation of the stem cells may be interchanged. The differentiation of the mesenchymal cells is directed by the force of external conditions whether these conditions consist in the special

physico-chemical milieu of the vessels or in an impulse through an enzyme-like material.

17. The effects of light on the retina of the turtle and of the lizard. SAMUEL R. DETWILER, Osborn Zoological Laboratory, Yale University. (Introduced by R. G. Harrison.)

Although the effects of light on the Reptilian retina have been studied by many investigators, differences of opinion still exist as to the results obtained. According to most investigators (see Garten) no migration of the epithelial pigment takes place, nor do the cones contract. The present investigation was taken up with the hope of finally ascertaining whether or not light had these effects on the retina of reptiles. Coincident with this work it was found that the anatomy of the retinae studied differed in some respects from that of other forms and it was therefore necessary to make an anatomical study which might serve as a basis for physiological experiments.

If the form of the outer segment of the visual elements be taken as the criterion in determining the differences between rods and cones, then it can be said that the retinae of the turtles, Chelopus guttatus, Chelopus insculptus and Chrysemys picta and of the lizard, Sceloporus undulatus, contain no rods. Both double and single cones occur.

Garten's explanation of why the pigment migrates and the cones contract in light necessitates the assumption that, in a retina in which the visual elements are all of one kind, these reactions do not take place. Nevertheless light brings about not only a migration of the retinal pigment but a shortening of the cones in both the turtle and lizard. When the eyes of animals which have been placed in bright sunlight for 6 hours are compared with those of animals kept in darkness for 24 hours it is found that light causes a forward migration of the pigment in the turtle (Chrysemys picta) on the average of 3.6μ and in the lizard (Sceloporus undulatus) of 3.1μ. In addition to this effect on the pigment it is found that light causes a contraction of the cones to the extent of 2.3μ (based on a series of 10 measurements) in the turtle retina as well as a flattening of the pigment epithelial cells of 2.7μ.

Not only are these changes brought about in normal eyes, but also upon eyes the optic nerves of which have previously been severed. In such cases the pigment in the light eyes is 2.5μ nearer the external limiting membrane than in the light eye with the nerve intact, but this does not represent a greater relative amount of migration. The pigment in the dark eye in which the optic nerve is cut is 4μ nearer the external limiting membrane than in a dark eye with the nerve intact. A series of measurements show that the migration caused by light in eyes with the optic nerves cut is on the average of 2μ in contrast to a migration of 3.6μ in normal light eyes.

In addition to these effects, light is also found to reduce the amount of chromatin and Nissl substance in the ganglion cells so that they stain less darkly and more diffusely. It also decreases slightly the ability of the outer nuclei to take on stain, but, while it does cause

them to lengthen slightly, it has no effect on the form and volume of the ganglion cells.

Attempts to see whether the pigment could be induced to undergo a greater migration by means of stimuli other than light were carried out by stimulating with currents, both interrupted and constant. Stimulation of the enucleated bulbus with an interrupted current of moderate strength brings about a position of the pigment approximately equal to that produced by light i.e., a migration of about 3.6μ.

Constant currents of 18 M.A. passed through the eye either in a centrifugal or centripetal direction for a period of 15 minutes cause a migration of approximately 2μ more than that produced by light. It also results in a considerable elongation of the cone myoid.

18. The development of function in the Purkinje cell of the dog and its relation to growth. (Lantern.) David H. Dolley, Laboratory of Pathology, University of Missouri. (Introduced by E. R. Clark.)

Postdivisional growth and the development of function proceed simultaneously in the Purkinje cell of the dog's cerebellum. An elemental analysis has become possible, first, because function from its definite morphology can be investigated as a process independent of growth, and second, very exact limits for the strictly developmental progress of both can now be set. Viewing growth independently, it is the resting cell type, uninvolved in function, through which the line of growth proper is accurately to be traced. As to the limits, the beginning is from a cell just out of the divisional phase, so embryonic that the cytoplasm is minimal. The terminal definitive period is set by the attainment of the nucleus-plasm norm standard for the species under the law of its species identity formulated by Dolley (Jour. Comp. Neur., 1914, vol. 24, 445).

Considering first growth separately, as expressed by nucleus-plasma coefficients, measurements of fourteen puppies of various ages show a steady progress with minor variations from coefficients of approximately 0 to 0.4 in the fetus at term to the adult norm of 11+ at five to six weeks.

It is not in the slightest conflict that there remains the potentiality of further growth for the infantile animal after six weeks. What has become constant is the nucleus-plasma relation. This post-developmental growth can be demonstrated to be identical with the growth which results from functional usage, the functional hypertrophy. There is an increase in the absolute size of nucleus and of plasma, but the same quantitative ratio holds between them in conformity to the law of species identity. It follows that the substances remain the same, and post-developmental growth, whether it is an undergrowth, an overgrowth, or maintains its status quo, is quantitative.

Considering next the phenomena of function separately, its morphologic changes become measureable at 10 days, though recognizable in immature form as early as 6 days. The conclusions of this paper, based on volumetric data, go no further back than the 10 day period. Meas-

urements of resting and functioning cells were made at 10 days, 17 days, and 27 days, and compared with the adult in respect to volumes and nucleus-plasma coefficients. There is complete objective homology between the curves of activity at all periods, and therefore the mechanism of infantile function is identical with that of the adult. Further, it is shown by plotting the data that there are definite quantitative levels, and that the changes of activity for any period are quantitatively based on the nucleus-plasma figure which subtends the resting cell belonging to that period. However, the limitations of average measurements of consecutive stages are too great to permit of an independent induction of the quantitative nature of infantile function and growth, though the indication of this is strong.

That adult function is quantitative is sufficiently established. That adult growth and overgrowth are quantitative is true if the law of species identity holds. The premise that was lacking in extending the quantitative principle to the developing cell is whether the substances of that cell, those involved in growth and those involved in function, are identical with the adult materials. In default of chemical knowledge, one has to turn to the mathematics of chemistry. Constant proportions for corresponding stages must indicate a constant chemistry. If there is the same proportion between resting cell infant and functioning cell infant as between resting cell adult and functioning cell adult, and if, as would follow, there is a common ratio of infant to adult for all phases at any period, it could only mean the same proportion of combination and nucleus-plasma interchange, and on a chemical basis, the same substances. Differences between infant and adult would be reduced to one of quantity for both function and growth.

In search of such exact proportions, resource was again had to the method of wax reconstructions of individual cells from one micron sections in serial. This gives the dual possibilities of determining the relative mass of plasma and nucleus by weighing the models and of applying the prismoid formulas for volume estimation, a mutual check. Two series of 12 adult functioning cells and of 15 infant, ranging from Stage 6 to Stage 9 (Dolley, Jour. Med. Research, vol. 22, 1910) were made and the data plotted in comparison with those of two series of 5 resting cells each from the same adult and infant. There was an identity of proportion lacking 0.24 of 1 per cent for the wax data and 1.5 per cent for the data of prismoid formulas, and the results were within the limits of the mathematical probable error.

The conclusion is indicated that back to the 10 day period the substances of the infantile cell are identical with the adult. The substances being identical, the quantitative principle may be independently induced as the basis of both developmental function and growth in common with the adult. Analyzed separately, the residuum of stable intrinsic substances which provide for growth and recuperation may be distinguished from the superficial transitory substances devoted to immediate energy liberation, the chromatin and nucleolar substance which disappear with work and return with rest. Each group must

have a constant ration to the whole, that is, a constant chemical constitution, otherwise the sum total of constancy would not be maintained.

What then is the relation of these two processes, each embodying a common principle, to each other? The nerve cell is the embodiment of a single attribute, irritability. In this it conforms to the law of the specific energies of protoplasm. All stimuli produce only a quantitative reaction. Its growth, therefore, must be conceived to relate only to that attribute. The substances which primarily grow are themselves preparatory and solely devoted to function. In the chromatin may be seen an end product of nucleus-plasma interchange and synthetic upbuilding destined to be transformed into the kinetic energy of function. Recuperation after the exhaustion of chromatin is as much a growth as is the infantile development of chromatin. Function then fundamentally rests upon the residual more stable substances which provide the passing material for each cycle of activity. Function further brings in no new element. It involves the same substances in a quantitative increase or decrease which are in metabolic equilibrium in the resting cell.

The phenomena of growth and function in the nerve cell are therefore concurrent, coinciding phenomena. For function it needs only to be shown that it is propogative, that the reaction of function is to excite the upbuilding of more materials for more function, and the whole growth phenomenon becomes merged in function, a property of function. It is an established principle of pathology that such is the inevitable effect of continued function, witness the functional hypertrophy.

Developmental growth, therefore, is a functional growth.

If growth of the nerve cell after division ceases is a functional growth, reversely, without function—that is, in the absence of stimuli—there should be no growth. This points the way to the experimental test of the conception.

19. The size of the medullated axons of the Purkinje cerebellar neurons in the albino rat. Elizabeth H. Dunn, Marine Biological Laboratory, Woods Hole.*

Golgi material shows us that the axons of the Purkinje cells of the cerebellar cortex are efferent, but has not determined the relation of these axons to the medullated fibers of the cerebellar cortex.

While working over, for another purpose, considerable brain material of the albino rat, I found that in some of the double stained material the relation of the medullated sheath to the Purkinje neuron could be determined. The medullated sheath was laid on very close to the neuron body, and the medullated fibers thus formed were among the largest found in the cerebellar cortex. The medullated process appears, therefore, to be correlated with the size of the neuron body which is the largest appearing in the cerebellar cortex.

See 66, Herbert M. Evans, page 264.

20. On the reversal of laterality in the limbs of Amblystoma embryos.
Ross G. Harrison, Osborn Zoological Laboratory, Yale University.

For the purpose of investigating certain factors concerned in the development of paired limbs a series of experiments have been made upon Amblystoma embryos. That portion of the body wall from which the fore limb normally develops was excised before differentiation had begun, and the disc-shaped piece thus obtained and consisting of ectoderm and mesoderm, was transplanted to another embryo. The results were as follows:

1. A limb bud from one side of the body implanted in the place of a bud previously removed on the opposite side, develops in a large proportion of cases (over one-third) into a limb of the side to which it has been transplanted, i.e., its laterality is reversed. The limb thus grown is in most cases perfect in form and function, though it is usually somewhat retarded in development as compared with the normal non-transplanted bud. Perfect regulation of the transplanted part with respect to the organism as a whole is thus brought about. In other cases (almost one-third) duplicate limbs arise, the twins being of opposite laterality. Observation of many of the cases in which single normal limbs develop shows that in early stages the bud tends to grow out as of the side to which it originally belonged, i.e., not reversed; then a reduplicating bud appears and this soon gains the upper hand, ultimately becoming the limb with reversed laterality, while the original is resorbed or in some cases reduced to a small spur which may remain permanently attached to the fully developed limb. In a few cases a single limb of original laterality develops though none of these have been found perfect. In the remaining cases the limbs are either rudimentary or the transplanted tissue is entirely resorbed.

2. If the limb bud from one side of the body is transplanted to the opposite side and placed not in normal position but on the side of the body between the fore and hind limb, the results are very different. A much larger proportion (over half) develop very imperfectly or are absorbed, about one-quarter develop with their original laterality and some reduplicated appendages may arise. In but one case has the laterality of the single limb been reversed.

3. In cases where the limb bud is implanted in normal location on the same side but turned upside down, about one-third of them develop into normal limbs in normal position. About one-sixth give rise to twin limbs and the remainder are mostly imperfect or are resorbed. Observation of the development in individual cases shows that the single limbs gradually acquire their normal orientation by rotation.

4. Limb buds placed upside down on the same side of the body between the fore and hind limb develop in one-half of the cases into limbs of opposite laterality. In no case has a single limb of the original laterality been produced and in only one case a pair.

5. Experiments in which the limb bud was transplanted to the same side of the body in normal position all resulted in normal development, showing that the results of the previous experiments are due to the

abnormal relations of the transplanted rudiment with respect to its surroundings, and not to the operation as such.

21. Changes in the chemical composition of the entire body of the albino rat during the life cycle. S. HATAI, The Wistar Institute of Anatomy.

The entire body of the albino rat was analysed at birth and at 7, 15, 22, 28, 35, 42 and 294 days and the variations according to age were determined for water and solids, and from the solids for the following chemical components: protein, fat, organic extractives and salts. The stomach contents of the young rats fed by the mother's milk exclusively were analysed also. Analysis of the stomach contents suggests that the milk of the albino rat is highly concentrated and rich in fat.

(1) The percentage growth of the solids reaches nearly a maximum (30 per cent) while the young are still nourished almost entirely by the mother's milk (end of third week). At the end of 42 weeks the additional growth in solids is only slightly over four per cent.

(2) The components of the solids show the following age variations:

Protein. The protein content is highest at birth and diminishes gradually until the end of the lactation period after which it rises again slightly.

Fat. The fat content rises rapidly during the lactation period after which it diminishes steadily.

Organic extractives. The organic extractives decrease rapidly towards the end of the lactation period, after which there is another steady increase. In general the variation in the organic extractives is similar to the variation in the protein.

Salts. The salts show a slight progressive reduction during the lactation period, after which they increase steadily.

(3) When the chemical compositions of several mammals are compared with one another it appears that the bodies of these mammals during growth pass through identical phases of chemical alteration, so far as the water, protein, fat and ash contents are concerned, and that the percentage of water is an indicator of the corresponding phases of the chemical alteration in different species, while neither the calendar age nor body weight of the animals can be used for the same purpose.

22. Some results from reversing a portion of the spinal cord end for end in frog embryos. DAVENPORT HOOKER, Anatomical Laboratory of the Yale University School of Medicine.

A piece of the spinal cord, together with the skin covering it and the dorsal portions of the myotomes, was excised from frog embryos in the closed neural tube stage, turned end for end and grafted into the space from which it had been removed. The cephalic end of the cut passed through the extreme caudad end of the medulla. The pieces were about one mm. long. In the majority of cases the reversed piece healed readily in situ. Twenty-four to forty-eight hours after operation, the head region cephalad to the cut responded to light mechanical stimulation of the body caudad to the grafted piece. On the second to the fourth day after operation, the embryos moved spontaneously.

The portion of the dorsal fin that was reversed with the piece of the spinal cord continued to exhibit its original polarity. This became more marked as the embryo increased in size. With this exception, many of the operated embryos were entirely normal in appearance. They grew well, reacted to stimuli in the normal manner and behaved as normals.

Microscopic examination of the reversed cord shows that in the majority of cases the fusion of the cord ends had successfully taken place at both ends. The original caudal end of the reversed piece, now directed cephalically, has fused with the medulla. The canalis centralis has in every case widened so that the transition from the large cavity of the medulla to the narrower canal of the cord is a gradual one. The reversed portion of the medulla, now lying at the caudal end of the reversed piece, has not disappeared. In all but two cases, it is present as a distinct enlargement of the canalis centralis. This enlargement, like the medulla itself, has an extremely thin roof.

In a few cases, the notochord was injured in the operation. In one or two of these embryos, its end became turned up between the cut ends of the cord. While this presents a mechanical obstacle to the healing of the cord that at times effectually prevents the process, it is perfectly possible for the cord to regenerate around it. This is accomplished by the outgrowth of nerve fibers from both ends of the cord and the prolongation of the canalis centralis either to one side of the obstacle or in such a manner as to envelop it.

A very interesting problem is raised by some of those embryos in which the cord ends did not fuse. Even in those cases where the lack of fusion was apparent at both ends of the reversed piece, the embryo was capable of fairly well coordinated movement during the beginning of the development of the swimming reflexes. The question raised here, as also by the embryos with completely severed spinal cord described in the Journal of Comparative Neurology for October, is whether the first swimming movements in the frog embryo are in reality dependent on a fully developed, though primitive, reflex system as has been found to be true for Amblystoma by Herrick and Coghill. It seems at least possible that the coordination in the swimming movement during the early stages of its development is materially assisted by the drag on the skin over the myotomes produced by the side to side swaying of the head. Muscle tissue that is beginning its differentiation is peculiarly susceptible to such stimuli. If this be true, the coordination is mechanical and not nervous in nature. It is, further, lost very soon as is the response to this type of stimulus by developing muscle tissue.

23. On the growth of the albino rat as affected by environment and by feeding various ductless glands (thyroid, thymus, hypophysis, and pineal). E. R. Hoskins, The Institute of Anatomy of the University of Minnesota.

In this investigation were used 59 female and 73 male albino rats from 29 different litters. One or two of each litter were kept for controls, and the others distributed as nearly as possible among four other

groups, the two sexes of course being kept separately. Each group received on alternate days thyroid, thymus, hypophysis, or pineal substances in different amounts, and the control animals were given equal weights of muscle. Both dried and fresh glands and muscle were fed, but the same results were obtained in either case. All the animals were given whole wheat (Graham) bread soaked in whole milk as their regular diet. The total number of rats fed, the number autopsied in each case, and the amount of glandular substances fed is shown in the following tables:

TABLE 1—NUMBER

Group	*Total fed*		*Autopsied*	
	Males	*Females*	*Males*	*Females*
Thyroid	13	9	11	9
Thymus	12	11	9	11
Hypophysis	17	11	13	11
Pineal	11	12	10	12
Muscle (controls)	20	16	16	16
Total	73	59	59	59
	132		118	

TABLE 2—DOSAGE

Gland	*Dry*	*Fresh*
Thyroid	10 mgm. to 200 mgm.	40 mgm. to 800 mgm.
Thymus	15 mgm. to 300 mgm.	70 mgm. to 1400 mgm.
Hypophysis	5 mgm. to 100 mgm.	25 mgm. to 500 mgm.
Pineal	7.5 mgm. to 150 mgm.	40 mgm. to 800 mgm.
Muscle	8 mgm. to 160 mgm.	25 mgm. to 500 mgm.

Feeding was begun at 3 weeks of age and continued for varying lengths of time until the rats were from 10 weeks to 8 months of age. Each of the rats was treated individually, weighed frequently, and carefully autopsied at the termination of the experiment. The older or 'summer-born' control rats grow at about the same rate as described by some previous workers along this line, but most of the younger or 'winter-born' were considerably larger at every age beginning with 3 weeks. These averaged at 3 weeks 32.6 gms. (males) and 29.6 gms. (females); at 6 weeks 84.0 gms. (males) and 80.0 gms. (females); at 10 weeks 168.5 gms. (males) and 129.6 gms. (females); at 13 weeks 197.4 gms. (males) and 145.3 gms. (females). The figures given are for an average of only 15 rats of each sex in the control group, but since the gland feeding in the other groups had little or no effect on the growth rate of the body as a whole, these figures represent indirectly the approximate average growth of 46 males and 43 females.

The rapid growth of these animals as compared with the published norms for other albino rats selected at random may be due to one or more of the following causes. They were the offspring of a mixture of two different strains, they were kept in a well ventilated room in

large, clean, airy cages, they received three times a day an abundance of wholesome food, and once a day clean water. The temperature of the room was carefully regulated. Of these factors the diet is probably the most important. A growth norm should be established for each group of experimental animals.

Measurement of the tails of 59 male and 59 female rats at autopsy showed that, as has been noted, males have relatively shorter tails than do females. The tail-body ratio in rapidly growing rats averaging 13 weeks of age was about 85 per cent for females and about 80 per cent for males. The tail of these rats was relatively shorter than that of previous norms.

The relative weights of the parts and organs of the control rats agree in most cases fairly well with previously published data.

Thyroid substance fed to rats had little if any effect at all on the growth rate of the whole body as compared with the control rats.

Autopsy showed that there was a slight loss of fat from the skin and the body cavity but the weight of this was made up by the overgrowth in some of the organs of the thyroid-fed animals, as compared with the controls. The heart of the thyroid-fed animals when compared with the controls showed an increase in relative weight of from 30 to 50 per cent in all rats of both sexes except in the case of a few males which received very small doses. The liver was increased in relative weight over 20 per cent in all but the few males just mentioned; the spleen is also more than 25 per cent heavier in the thyroid-fed rats, but this organ is extremely variable. The relative weight of the suprarenals was increased by from 17 to 45 per cent in the females and over 50 per cent in the males, excepting the few which received small doses. The kidneys were increased to about the same extent as the liver.

Other organs showed a constant hypertrophy to a lesser extent among the thyroid-fed animals, but the difference in these might possibly be accounted for by chance variations. These parts are the alimentary canal, testes and hypophysis (male). A still smaller increase in weight is shown by the skeleton, pineal body, brain and eyeballs. The variation in this last group of organs might well be due to normal variability especially as the number of data is not large.

In none of the groups of rats fed with thymus, hypophysis (whole), or pineal were constant differences in relative weight of the body or of the organs or parts demonstrable, except such as possibly can be explained under normal variability. These will be discussed in a later paper.

24. The renal tubules of birds. G. Carl Huber, University of Michigan.

The author, after completing a study of the development of the mammalian renal tubule, in which the Born reconstruction method was freely used, projected a study on the morphology of the renal tubules of vertebrates. The renal tubules of the frog (mesonephros) and of several reptiles, (Chrysemys marg., Alligator miss., and a lizard) were readily reconstructed. For the time the reconstruction of the renal tubules of adult mammals and birds, owing to the long medullary loop, seemed

beyond the reach of possibility. A method for completely isolating the renal tubules of mammals by teasing was later developed, by means of which it was possible to isolate complete renal tubules of an adult mammal (rabbit) and to determine the characteristic epithelium of their different segments. After further interruption of study of the renal tubules of birds was undertaken, as here reported. The bird's kidney studied was that of the chicken (roosters, two to four years old); the method of maceration and teasing, that developed by the author; injection of 75 per cent hydrochloric acid through the arterial supply, teating under water with the aid of a steroscopic binocular. Many complete renal tubules of the bird's kidney attached to portions of the duct system have been isolated.

The kidney of the bird is of special interest in that it presents a transition stage between the simple renal tubules without medullary loop as observed in reptilia and the more complex tubule with long medullary loop having distinctive epithelium as observed in mammalia. A bird's renal tubule of the mammalian type possesses a relatively large renal corpuscle and glomerulus, a relatively long proximal convoluted portion, a proximal limb of the medullary loop with flattened epithelium, the loop itself and the distal limb of the medullary loop with short cubic epithelium and a relatively long, much-coiled distal convoluted portion. The bird's renal tubules of the simplest type—reptilian type—present relatively small renal corpuscles and glomeruli, with the tubular portion arranged in the form of a compressed W; the proximal V, near the glomerulus, presenting the epithelium of the proximal convoluted portion, the distal V, joining the duct, being lined by short cubic epithelium. Intermediate types, ranging between the mammalian and the reptilian types of tubule, are observed.

25. The significance of different and distinctive types of bronchial architecture within the same order of mammals. GEO. S. HUNTINGTON, Columbia University.

The detailed study of the bronchial system of mammalia reveals within ordinal and generic groups individual forms which differentiate themselves sharply in the architecture of the bronchial tree from the prevalent bronchial type found in all other members of the group to which the aberrant forms are zoologically assigned. In some instances the departure in bronchial organization typical for the remaining members of a taxonomic group may fairly be interpretated as a progressive adaptation to changed environmental conditions affecting respiration.

Thus, among rodents, in the subfamily *Hydromyinae*, *Xeromys*, a purely terrestrial form, exhibits the dominant asymmetrical bronchial type, common to most members of the order, with the eparterial bronchus confined to the right side. In its close relative, *Hydromys*, strictly aquatic inhabit, a symmetrical bilateral eparterial district has developed. The same condition is encountered in the aquatic rodent, *Myopotamus*, in which the left eparterial bronchus appears in association with the equally well developed left infra-cardiac bronchus.

These isolated instances of left eparterial bronchial extension in some aquatic rodents seem to place themselves in line with the corresponding pulmonary organization found in its full development in many of the pinnipede carnivores and some cetaceans.

The adaptation to aquatic life calls for more or less prolonged periods of suspension of respiration during submersion. Accessory modifications of the vascular system render possible the storing of CO_2 in the blood, until the same can be exchanged in large quantities and rapidly when respiration is resumed. The huge hepatic caval sinuses of *Phoca* and the enormous plexiform network of the abdominal and urogenital veins in *Macrorhinus* are examples of these secondary and associated vascular modifications. Under such conditions the process of respiration becomes exceedingly active and rapid. The lung responds to this heightened physiological demand by the greatest possible unfolding of the respiratory area. The ultimate respiratory expansion in any mammalian lung is in direct ratio to the distances separating the origins of the primary derivatives from the stembronchus and to the calibre of the tubes. The physiological significance of the eparterial bronchial development is the attainment of the greatest possible interval between the origins of the first and of the succeeding tiers of primary bronchi from the stembronchus, with the resulting greater unfolding of the respiratory area in the cranial divisions of the lung. The latter, in lungs with fully developed eparterial districts, show increase in size, more complex lobar organization, freer mobility in expansion and in adaptation to the topographical conditions of the thorax and its contents. They become distinctly more efficient organs.

The same significance attaches to the right tracheal eparterial bronchus found uniformly throughout the Artiodactyls, and to the bilateral eparterial development of the Perissodactyls and Proboscideans. Here increase in pulmonary development is apparently called for by massive bulk, great muscular development, and, in many forms, by the necessity for rapid and long continued locomotion, all factors calling for increased tissue combustion and active respiratory exchange.

Respiratory metabolism throughout the vertebrates appears reflected in pulmonary structure primarily in reference to the *rapidity* with which the gas exchange is to be effected. All more highly organized complex lungs indicate either a high rate of tissue combustion at a fairly *constant* ratio (Ungulates), or a rapid metabolism called for at *definite intervals* (aquatic adaptations), with intermissions, during which respiration is suspended. The lung appears to acquire morphologically the development corresponding to the highest degree of efficiency which can be functionally demanded in any given form under all conditions.

The organ is, so to speak, overpowered for the work it ordinarily has to perform, but is hence capable of responding to unusual demands.

While many of the aberrant lung types among mammalia may thus be analysed as adaptations to specialized environmental factors, others do not fit themselves into this interpretation, and call for special consideration.

A distinctive bronchial type, in which all primary derivatives arise from a distal tracheal enlargement (bulla) and unfold as bilaterally symmetrical hyparterial bronchi, is found among the rodents, in some *Hystricomorphs* (*Hystrix cristata*) and in one member of the carnivore family of the Mustelidae, *Taxidea americana*. In all the other Mustelidae, whose pulmonary organization is known, and at least in some of the Hystricomorphs, the dominant mammalian asymmetrical bronchial tree obtains.

Both animals possessing the aberrant pulmonary pattern fairly conform to the nearest associated types in the carnivore and rodent groups to which they are respectively assigned, in respect to weight, body-build, habitat, mode and speed of locomotion, hibernation, etc., all external factors which might be regarded as influencing pulmonary development. Likewise in food habits, dentition and alimentary canal they agree with their zoological colleagues—*Taxidea* has an alimentary canal which, in respect to the structure of the stomach, the relative length of the individual intestinal segments, the simple ileo-colic junction without caecum, can hardly be distinguished from that of *Meles*. *Hystrix* conforms in every particular of its alimentary canal to the rodent type.

We are hence confronted by the important question as to the value of pulmonary organization in determining phyletic relationship. In spite of the nearly congruent structure of all parts subject to the external influences of environment and food, *Taxidea*, in its pulmonary ground plan, is not a typical Mustelid badger, nor, judged by the same evidence, does *Hystrix* agree with all other rodent porcupines.

To take the case of *Taxidea* for closer examination, the morphological facts may be analysed in one of four ways:

1. My friend, Prof. William K. Gregory, of the American Museum of Natural History, who has devoted especial attention to the phylogenetic history of the Mustelidae, derives the extant members of the group from the lower Oligocene *Plesictis*. Accepting *Plesictis* as the common ancestor of the modern Mustelidae, it is possible to assume that the Plesictis-lung was constructed on the bilateral symmetrical hyparterial type, retained today in only one of the living descendants, *Taxidea*, while in all other recent Mustelidae, as far as known, environmental changes have so altered the constitution of the germplasm as to produce the changed pulmonary type with right eparterial development.

It is probable that the influence of changed environment upon the developing germ cells, and through them on evolution, has, if anything, been underestimated in the past, as notably by Weismann. But in the case in hand, the above outlined hypothesis is untenable, because all our available evidence proves the mammalian lung to be extremely sensitive in its structural response to environmental demands. Witness the above cited instances of pulmonary adaptation in isolated members of rodent groups to aquatic life furnished by *Hydromys* and *Myopotamus*. Now any changed environment capable of producing

chromomeric alteration in the developing germ cells of the *Plesictis* descendants must have operated equally and evenly on all to produce the prevalent Mustelid type. On no possible grounds could *Taxidea* be exempted, when in all other environmental adaptations it conforms to the other members of the group. The lung of *Taxidea* is unquestionably physiologically as efficient as are the lungs of the other Mustelidae. Its occurrence in this form, which in general body structure, alimentation, locomotion, habitat, etc., agrees with its other taxonomic colleagues, alone proves this. Otherwise *Taxidea* would either have become extinct or its lung would have adapted itself structurally to the new demand. The perpetuation side by side of the Taxidea lung and of the prevalent pulmonary type of the other Mustelidae disproves the premises on which the first hypothesis is based.

2. It might on the other hand be reasoned that the Plesictis lung had already developed the dominant dextral eparterial distribution, transmitted unchanged to all of the modern descendants, with the single exception, as far as known, of *Taxidea*. In *Taxidea* pulmonary reduction occurred, resulting in the loss of the right eparterial lung segment and the acquisition of the tracheal bulla.

Aside from the fact that no environmental changes are known, capable of inducing this reduction and confined in their operation to *Taxidea* to the exclusion of the other Mustelidae, the above supposition assumes morphogenetic processes, which on close examination we find nowhere in the mammalian series. I know of no single instance of even a probable reduction of a formerly developed pulmonary element in a mammal. In fact the phylogenetically acquired metameric reduction of the trunk cavity in mammalia would of itself negative this assumption. The inclusion of the cardiac lobe in the phrenico-mediastinal angle of the right lower lobe in man and some other mammalia is merely in consequence of the closure of the pericardio-phrenic space consequent upon the fixation of pericardium to diaphragm. The morphological character of the lobe is retained in the cardiac branch of the right stem-bronchus.

D'Hardiviller's discovery of an ephemeral left eparterial bronchial vesicle in the embryo of the rabbit, if confirmed, points far more directly to an attempt on part of the left lung to acquire additional respiratory territory, than to the evanescent appearance during ontogeny of a pulmonary element lost in the phylogenetic evolution of the mammalian lung. This is confirmed by the occurrence of adult bronchial variants. I think we are justified, on the basis of all of our actual facts, in concluding that any mammalian lung which has once acquired a focal point of entodermal bronchial proliferation, retains that point in its structural organization of the lung, even against apparently unfavorable local and topographical modifications, as e.g., of the thoracic space.

Neither of the above hypotheses 1 and 2 answer in any way the problems raised by the aberrant pulmonary type of *Taxidea* and *Hystrix*. Neither offer more than agnostic circumlocution, a pseudo-scientific way of leaving them unexplained.

3. The assumption that the lungs in question are the result of variation by mutation in one of the phylogenetic lines, transmitted by inheritance to the modern descendants, is the only one compatible with the acceptance of a monophyletic derivation of the aberrant types. It labors under the enormous handicap that mutations of this degree, affecting exclusively a single organ system, are heretofore unknown in mammalian organogeny.

4. *Hystrix* and *Taxidea*, conforming in skeletal and alimentary characters to the respective rodent and carnivore types with which they are zoologically grouped, yet differ from them radically in their pulmonary organization. This difference is not one of degree, not merely an exaggeration or reduction of a pulmonary character common to all mammalia. It is fundamental, inherent in the genetic groundplan of the organ, and it manifests itself in the earliest ontogenetic differentiation of the endodermal lung tube. Its development implies a histonal selection differing from that governing the genesis of the dominant mammalian type. Comparison of the lung of *Taxidea* with that of *Meles*, or *Mephitis* or *Gulo*, or of any one of the Mustelidae, whose pulmonary organization is known, render the conclusion inevitable, that the same germplasm, or the same determiners of the chromomeres, cannot be held responsible for the production of these divergent results in adult structure. The modern zoological groups of the carnivore Mustelidae and the rodent Hystricomorphs contain, therefore, today on the evidence of their lung structure, each a form which departs so fundamentally in this regard from its respective colleagues, as to create at least a grave doubt concerning their germinal kinship. These considerations raise the question as to a diphyletic origin for certain of the modern zoological groups. It is possible that all the external congruent characters uniting two given types are the results of a high degree of convergence and adaptation to identical conditions of habitat, locomotion, alimentation, dermal protection and other environmental factors.

26. An interpretation of connective tissue and neurogliar fibrillae. Raphael Isaacs, from the Anatomical Laboratory of the University of Cincinnati. (Introduced by H. McE. Knower.)*

Observations on Connective Tissue and Neurogliar Fibrillae. The study of living connective tissue in cover glass and hanging drop preparations, checked up by experiments with gelatin, albumin and fibrin, and compared with fixed tissue, shows the intercellular substance to be homogeneous, that is, without a formed network in the ground substance in the living condition. The methods and materials used, confirm many points described by different investigators and suggest interpretations of others. The connective tissue fibrillae, described as exoplasmic fibrillae by Mall and others, as well as the corresponding fibrillæ of neurogliar tissue, do not appear in the living intercellular connective tissue colloid, as they arenot visible in the living tissue, nor can they be demonstrated by stains or optical methods. They can be produced in fresh tissue under the microscope through any agency

which will cause the material, which is distributed in the intercellular spaces, to shrink up. This shrinkage produces fibrillae with spaces, formerly occupied by the ground substance, between them. The possibility of washing out interfibrillar substance is eliminated by this method. The pattern and delicacy varies with different fixatives and resembles the pattern of the fibrin coagulum in the blood vessels. The freedom of movement of the cells and the appearance of fibrillae across gaps in separated pieces of tissue which had been placed in contact and fixed in this position, further supports the view of the origin of the fibrillae by the coagulation of the ground substance. The fact that the white fibers and elastic fibers of the tissue, when first formed, have a jelly-like consistency, and not the consistency of a transformed network of preexisting fibrillae, is additional evidence. The fibers, studied stage by stage, are shown to become progressively stronger and denser by the concentration of their material through increased deposit of substance. The movement of the connective tissue cells probably effects the distribution of the material through chemical or other action and causes the fibrillated structure of the adult fibers.

Forces acting on the jelly-like embryonic connective tissue affect the cells and colloid alike, but the cells have the power to readjust themselves to the new condition, thus producing permanent structures in reaction to pulls and pushes.

The colloid is continuous between the cells and is more jelly-like than either lymph or blood. No free-flowing intercellular fluid could be demonstrated.

The spindle-shaped type of connective tissue cell appears to be the most stable form, the stellate cells often reverting to this shape when freed from the surrounding pressures. The cells lie free in the colloid in the younger embryos and can be easily separated mechanically. This observation is in accord with the findings of Clark, Ferguson and Stockard, that the mesenchyme cells in embryos exercise the power of active locomotion.

By means of experiment with fresh tissues, it is found that the fibrillae of fixed tissue span cut surfaces which had been allowed to touch. This would suggest that if pressure were exerted on an embryo, (the contraction on fixation,) early lymphatic anlagen, which have been described as irregular spaces in the mesenchyme, and which are at first not lined by typical endothelium, could be closed in places by these 'fixation adhesions.' As the weaker colloid of younger embryos leaves less precipitate than that of the older stages, we can assume that regions of less concentration in the older embryos will exhibit more delicate fibrillae. As such regions have been described (Kampmeier) it is probable that we have pathways physiologically determined by the establishment of regions of less concentrations. Into these, capillaries may grow by following the lines of least resistance. This would seem possible from the fact that young capillaries, both blood and lymph, show no condensation of connective tissue cells around them, as do the more solid organs as the salivary glands, thyroid and thymus, which have pushed into the more dense tissue.

27. Effects of inanition upon the structure of the thyroid and parathyroid glands of the albino rat. (Lantern slides.) C. M. JACKSON, Institute of Anatomy, University of Minnesota.

The material for this study was derived from numerous young rats held at constant body weight by underfeeding for various periods, and from adult rats subjected to acute and chronic inanition.

In the younger rats, the histological changes are varied as follows. The nuclei of the follicular epithelial cells in many cases undergo chromatololysis (various stages of karyolysis), and are sometimes swollen. Hyperchromatosis, however, is more frequent. Some stage of karyopycnosis is usually present. In earlier stages the nucleus may be nearly normal in size and structure, excepting a pale homogeneous coloration of the nuclear background. In more advanced stages the nucleus diminishes in size, with deepened coloration, forming a dense homogeneous mass (typical pycnosis). In extreme cases the nucleus becomes fragmented (karyorrhexis). Mitosis is never found.

The cytoplasm of the follicular epithelium is usually reduced in amount, but may show no marked change in structure (simple atrophy). Sometimes the cytoplasm is not reduced in volume, but in this case it always appears rarefied, with decrease of the normal granulation and usually with marked vacuolization. In advanced stages, the cytoplasm may disintegrate, forming irregular, deeply-staining masses of varied appearance.

The intrafollicular colloid may show no abnormal changes. Advanced stages of degeneration in the follicular epithelium, however, are accompanied by dissolution and distintegration of the colloid. The colloid is often replacd by desquamated epithelial cells in various stages of degeneration, and the entire follicle may collapse into an irregular mass.

The interfollicular connective tissue (stroma) usually shows no marked change in structure, but in some cases the ground substance is greatly increased in amount, giving an edemic appearance. On this account, a gland may show little change in gross weight, although there has been a marked atrophy of the parenchyma.

In the adult rats subjected to acute and chronic inanition, the changes in the structure of the thyroid gland are likewise varied, but in general appear similar to those found in the younger rats. The interpretation of the changes in the older rats is more difficult on account of the frequent occurrence in the normal (control) rats of degenerative changes similar to those found in advanced stages of inanition.

The parathyroid gland is in general more resistant to inanition. The effects upon its epithelium are somewhat similar to those described for the thyroid, though usually less marked. The nuclei may remain nearly normal in size and structure, though usually slightly smaller and exhibiting various stages of karyolysis or (more frequently) karyopycnosis. Mitosis ceases. The cytoplasm may be either reduced in amount (sometimes deeply staining) or may remain normal in volume,

with marked vacuolization. The stroma may remain normal in amount or may be increased in volume by infiltration of ground substance. Variations also occur normally in the structure of the parathyroid (through less marked than in the thyroid), so that here likewise caution must be observed in drawing conclusions as to the effects of experiments.

28. Notes on the neuromeres of the brain and spinal cord. (Lantern.) FRANKLIN P. JOHNSON, University of Missouri.

While studying a human embryo of 23–24 segments (a description of which is now ready for publication), it was discovered that not only does the rhombencephalon possess neuromeres, but the whole medullary tube as well is definitely marked by a series of alternating constricted and expanded portions. The fact that the medullary tube possesses neuromeres has apparently been overlooked in the numerous descriptions of young human embryos. Minot (Human Embryology, 1892) however, noted their presence in mammalian embryos, and recently Watt (Carnegie Contributions to Embryology, vol. ii, 1915) observed them in twin human embryos of 17–19 segments. I have since found them to be constant in all other young human and pig embryos which I have examined. The present work was undertaken to determine the similarities which exist between the neuromeres of the brain and spinal cord, the relations of the nerves to the neuromeres, and the relations of the neuromeres to the body segments. The following points have thus far been revealed:

1. The neuromeres of the spinal cord are intersegmental in position, that is, the swelling of the neuromere is placed opposite the intersomitic spaces. This fact was noted by McClure (Jour. Morph., vol. iv) in embryos of amphibians, reptiles, and birds, and by Minot (Human Embryology) in mammalian embryos. The same is true of the neuromeres of the rhombencephalon in the region occupied by the occipital somites.

2. Each neuromere of the spinal cord gives rise to the ventral root and receives the dorsal root of a spinal nerve. Likewise the rhombic neuromeres, with the exception of the first and possibly the fourth neuromeres, give rise to and receive the motor and sensory roots of the cerebral nerves.

3. The relations existing between the neuromeres and cerebral nerves are as follows:

The first rhombic neuromere in the embryos I have thus far studied does not give rise to any nerve. It is possible, however, that the trochlear nerve is a later outgrowth from this neuromere.

The second and third neuromeres both contribute to the efferent root of the trigeminal nerve. Both receive the afferent fibers from the ganglion of the same.

The fourth neuromere gives rise to the efferent and receives the afferent fibers of the facial nerve. In addition it receives the afferent fibers of the acustic nerve.

The fifth neuromere gives rise to the abducent nerve, although this

nerve appears somewhat later than most of the others. In addition it receives a small number of the afferent fibers of the acustic and facial nerves. These fibers, however, enter the brain on the fourth neuromere and pass immediately in the brain wall to the fifth neuromere.

The sixth and seventh neuromeres give rise to the efferent and receive the afferent fibers of the glossopharyngeal and vagus nerves respectively.

The eighth and ninth neuromeres give rise to the efferent roots of the hypoglossal nerve. The eighth receives the afferent fibers from the root ganglia of the accessory nerve; the ninth, a few fibers from the root ganglia of the accessory nerve together with a few from Foriep's ganglion.

The succeeding neuromeres belong to the spinal nerves, the first cervical nerve to the tenth neuromere, the second to the eleventh, etc.

The lateral roots of the accessory nerve proceed from the eighth to the thirteenth neuromeres inclusively.

4. Since the first cervical nerve belongs to the tenth neuromere, the preceding nine belong to the rhombencephalon. The lower limit of the rhombencephalon may, therefore, be definitely defined in young stages as the constriction between the ninth and tenth neuromeres. This lies opposite the last pair of occipital somites.

5. The lumen of the central nervous system likewise shows expanded and constricted portions corresponding to the neuromeres and the depressions between them. This is well known concerning those of the rhombencephalon and easily demonstrable in case of those of the medullary tube.

29. A comparative microscopic study of cardiac and skeletal muscle of Limulus. H. E. Jordan, University of Virginia.

Limulus heart muscle in stained sections is practically identical with vertebrate heart muscle; it has a coarser texture, but it is syncytial in structure and contains a conspicuous telophragma or Z stripe, the Q and J stripes being generally indistinct. Skeletal (spine) muscle of Limulus, like that of vertebrates, consists of finer and more robust multinucleated fibers; but from the viewpoint of its myofibril arrangement and its cross striations it resembles more closely the cardiac type of muscle. Among the cross striations, the Z stripe is the most conspicuous. Moreover, the skeletal muscle, like cardiac muscle generally, lacks a mesophragma or M membrane. In both types of muscle, in the contracted condition, only contraction bands are visible; these are coarser darker discs at the levels of the telophragmata. In view of its detailed similarity to cardiac muscle, including the promiscuous location of the nuclei either centrally or peripherally in the fiber, the skeletal muscle of Limulus must be regarded as a less highly differentiate type of striped muscle.

The close structural similarity between cardiac and skeletal muscle in Limulus extends to still other details: The apparent fibrillar unit of structure, the myofibrilla or sarcostyle, resolves on higher magnification and under certain artificial conditions into still finer fibrils, to

the limit of visibility. This observation supports Heidenhain's 'Teilkörper Theorie' ('histomere' or 'protomere' theory) enunciated as a general histologic principle, and based largely upon the study of striped muscle development in trout (Arch. mikr. Anat. 83: 4, 1913.)

A sarcolemma is present in both cases, distinguishable from the closely investing endomysium by a different staining reaction to acid fuchsin. Meek (Journ. Morph. 20: 3, 1909) reported the absence of a sarcolemma in Limulus cardiac muscle. He conceives of this musculature as a double syncytium composed of trabeculæ 'individualized by connective tissue sheaths.' But with Van Gieson's stain, successfully applied, a delicate inner layer remains unstained, whereas the outer portion stains a light red color. When the application of the stain is unduly prolonged, the sarcolemma also stains red, but so do also the ground membranes, the nuclear membranes, and the peripheral sarcoplasm. Moreover, the muscle nuclei are larger, more vesicular, and more regularly oval than those of the intertrabecular endomysium.

This material furnishes precise data also with respect to the nature of the telophragma or ground membrane, and its relation to the sarcolemma and the nuclear wall. The Z stripe results from a continuous membrane extending completely across the fiber; to it are firmly attached bundles of the ultimate fibrillae, forming the so-called sarcostyles. At the point where fibrilla and membrane meet the latter appears to swell and presents the form of a spherical granule; this circumstance gives to the Z membrane a granular appearance. Peripherally the membrane unites with the sarcolemma, the latter frequently showing a uniform festooning. Centrally the membrane joins with the nuclear wall; the latter frequently, when in shrunken condition, presents a series of spinous projections, corresponding in number and spacing to the number and spacing of the corresponding Z membranes.

The continuity of the telophragma with the nuclear wall across the perinuclear sarcoplasm presents conclusive evidence against the interpretation of striped muscle structure in terms of 'muscle cells' and extracellular myofibrillæ, as first suggested by Apathy and recently again urged by Baldwin. (Zeits. f. Allgem. Physiologie, Bd. 14, 1912).

Nuclear multiplication in growing Limulus muscle is amitotic; as many as eight or even more nuclei may lie in series in a single sarcoplasmic area. Not a single mitotic figure occurs; but all stages in amitosis can be found.

In cross-section the myofibrillae of both types of muscle are seen to be arranged in radially placed lamellae; in the skeletal muscle these lamellae undergo peripheral radial and central tangential splitting, recalling an early ontogenetic phase in striped muscle histogenesis of certain teleosts, e.g., trout.

In an earlier study (Jordan and Steele, Am. Jour. Anat. 13: 2, 1912) I came to the conclusion, therein confirming Meek (1909), that intercalated discs are lacking in the Limulus heart. Reinvestigation with a different staining technic (iron-haematoxylin, after alcohol-nitric acid fixation) reveals a few discs of the simple 'comb' type. On the basis of

my interpretation of intercalated discs in terms of *irreversible contraction bands*, following strain incident to prolonged rhythmic contraction, intercalated discs would be expected to occur in Limulus heart muscle, since the latter beats rhythmically and has a structure essentially like that of vertebrate myocardium. In view of the slowness of the heart beat (about 20 to 32 beats per minute—Carlson; Patten), only a small number of discs of simple construction were to be expected. This expectation is actually realized; the intercalated discs are of the 'comb' type, and generally divide contracted from relaxed portions of the fiber, as is frequently the case in mammalian heart muscle.

The position of the intercalated disc at the level of the ground membrane, the firm union of the fibrillae to the membrane, and the resolution of the fibrillae into finer fibrils as seen in Limulus cardiac muscle throw light upon the origin of the serrated type of intercalated discs almost exclusively present in hypertrophied mammalian hearts, and to some extent in apparently normal mammalian hearts. What was difficult of interpretation hitherto was the character of the connecting substance between successive crests of the 'saw-toothed' discs (Anat. Rec. 6: 9, 1912). Hypertrophy is essentially a matter of fibril increase; moreover, in hypertrophied heart muscle the usual tensions among the fibrils are conceivably readily disturbed throwing adjacent fibrils out of functional synchrony and even placing them under directly opposed stresses. Granting the latter possibility, serrated types of discs are readily derived from simple straight 'comb' types by a splitting of the original sarcostyle, the resulting fibrils of which, after more or less complete separation at the level of the original 'comb' disc, are drawn in opposite directions, or for unequal distances in the same direction, the ground membrane meanwhile retaining its connection with the displaced division products of the disc, thus producing a serrated condition.

With respect to the mode of conduction of the impulse to heart beat the Limulus myocardium answers the requirements of the neurogenic theory (Carlson); vertebrate cardiac muscle apparently acts in accordance with the myogenic theory. But the two musculatures (Limulus and vertebrate) agree in their rhythmic functional activity, their syncytial structure, the presence of intercalated discs, and the presence and relationships of cross-stripes and sarcolemma. The difference in the method of impluse conduction inheres most likely in the absence in the Limulus heart of anything analagous to the longitudinal coördinating muscle bands, the atrioventricular conducting bundle of His, of mammals and certain vertebrates. Longitudinal muscle fibers are practically absent in the Limulus heart. As a consequence the only remaining mechanism which could mediate conduction of the impulse for the 'apparently instantaneous' (Carlson, Am. Jour. Phys., vol. 12, 1904) contraction of the whole series of the nine annular segments of the essentially metameric heart, is the longitudinal nerve cord.

The structurally different constituents of the Limulus sarcostyle are the Z membranes and the Q and J discs. Q and J most probably

differ only in the matter of a relatively greater abundance of certain darker staining materials (the so-called 'anisotropic granules') in the former. In the wing muscle of the fly Meigs, (Zeits. f. Allgem. Physiologie, 8: 1, 1908) recognizes only Q, Z and M; he regards J as the optical effect of a greater refractive index on the part of Z as compared with its enveloping substance, Q. That this interpretation cannot properly apply to Limulus muscle seems indicated by the relatively great width of J as compared with the Z membrane, and the different degree of stainibility of Q and J. Moreover, there is not the slightest indication of an M membrane, either in the cardiac or the skeletal muscle. Thulin (Archiv. mikr. Anat., 86: 3, 1915) records the absence of an M membrane also in the wing muscle of Coleoptera, and in the analogous (pectoral) muscles of birds and bats. An M membrane apparently only occurs in certain more specialized types of striped muscles; it is probably never present as a true membrane in cardiac muscle.

30. The development of the occipital region of the domestic cat with an interpretation of the paracondyloid process. JOHN D. KERNAN, JR. From the Anatomical Laboratory, Columbia University.

Investigators are by no means agreed as to the elements entering into the composition of the basal part of the occipital region. Weiss (1) working with rat embryos found that the basioccipital was formed from hypochordal elements exclusively, without body elements. Noordenbos (2) working with Talpa, and Gaupp (3) working with opossum and rabbit embryos confirmed the findings of Weiss. On the other hand, Froriep (4), with calf embryos showed that in this animal the basioccipital is formed through chondrification of perichordal tissue dorsal to the hypochordal arches. Thus, according to him, there is formed a body to the occipital vertebra; which later fuses with the bodies of the unsegmented vertebrae which form about the chorda in a more cranial position. The united bodies form the basioccipital to which are subsequently joined the independently arising arches. The hypochordal arches which appear in the early embryos are absorbed without chondrifying.

In view of these contrary findings, the conditions found in early cat embryos are of interest. In an embryo of 9 mm. four membranous arches can be made out in the occipital region. These show a row of dense masses laterally, joined ventrad to the chorda by hypochordal bars. These hypochordral bars are in contact with the chordal sheath, and form with it a row of perichordal crosses such as is found in other areas of the vertebral column. Of the four membranous arches which can be made out, the two cranial are indistinct and have a tendency to fuse.

In an embryo of 10 mm. the tissue of the lateral masses has advanced far toward chondrification, and they have begun to fuse longitudinally, forming two precartilaginous bars between which lies the chorda free of cartilage. These bars may very well be compared to the parachordal processes of lower vertebrates.

In an embryo of 11 mm., the lateral bars of cartilage have begun to unite across the median line ventral to the chorda. There is thus formed a cartilaginous trough in which lies the chorda, with no cartilage dorsal to it.

It must be noted that throughout the formation of the basioccipital as thus far traced no perichordal cartilage forms between the primitive arches, where the bodies form in other regions of the vertebral column.

In an embryo of 12.5 mm., for the first time, cartilage dorsal to the chorda is present. This is in immediate connection with the perichordal sheath, in an area craniad to the occipital region. At no stage does the chorda receive a dorsal cartilaginous covering in the occipital region.

Comparison of this mode of formation of the basioccipital with that of the other vertebra shows it to be the same as that by which the atlas originates, that is by chondrification of two lateral masses, which subsequently are joined by chondrification along the line of the hypochordal bar. The basioccipital of the cat then may be said to be made up of vertebrae of the atlas type. This view has already been suggested by the authors quoted, most clearly by Gaupp.

The paracondyloid process is ordinarily interpreted as being constituted by the transverse and costal processes of the occipital vertebra. It forms the ventral tip of a lateral expansion of the occipital wing, known as the 'lamina alaris' (Voit) (5). The lateral border of this lamina extends along the caudal margin of the otic capsule and fuses with it, thus forming the commissura occipito-capsularis.

Examination of a series of cat embryos from 15 to 35 mm., shows that the lamina alaris is connected with the occipital wing craniad and dorsad to the hypoglossal foramen. This would indicate that the lamina alaris and its free ventral tip, the processus paracondyloideus, belong, not to the occipital vertebra, but to the unsegmented vertebrae craniad thereto. An examination of a reconstruction of a 20 mm. human embryo and the sections of the same gives evidence for this interpretation. In the sections it is seen to consist of two parts as regards its cartilage, a lateral and a mesal. The mesal part is a lateral protrusion of the occipital wing. The lateral part is a bar of cartilage parallel to the mesal ridge, and in close contact with it, but showing a separation of its cartilage at certain levels. It is entirely independent at the tip. Then for a distance dorsal to the tip it is in close contact with the mesal part, but separated from it by a layer of perichondrium. Dorsal to this area of close contact, there is for a distance a fairly wide separation, then an area of complete fusion. Still more dorsally there is again an area of separation, then complete fusion, which is not again interrupted. From the tip of the paracondyloid process there extends mesad and craniad a thin process of cartilage which reaches the basioccipital dorsal and laterad to the hypoglossal foramen. This was found by Macklin (6) in his 40 mm. embryo, and bounded laterally and cranially a foramen which he termed paracondyloid foramen. It corresponds in position to a ridge of bone which in the adult passes from the jugular process

mesad and craniad to the basioccipital. It represents as Macklin suggests a costal process, not that of the occipital vertebra, but of one of the unsegmented vertebrae, probably the second, since its connection to the basioccipital and occipital wing are laterad and dorsad to the hypoglossal foramen.

The paracondyloid process then is the free extremity of the lamina alaris, and this has been shown to be a bar of cartilage uniting at intervals with the parallel ridge of the occipital. The outer bar represents fused costal elements, and may be termed the costal bar. The points of union correspond with the transverse processes, the areas of separation indicating the intervals between the processes of successive vertebrae. Three such processes can be enumerated. That of the occipital vertebra is small and shows no independence of the costal elements. The second vertebra shows an independent costal element which is drawn out caudad and forms the paracondyloid process. The most cranial vertebra helping to form the basioccipital shows no free costal element. The costal bar is prolonged upward on the occipital wing as a ridge which represents the inferior nuchal line of the adult bone. The caudal prolongation of the costal bar, the paracondyloid process, overhangs laterally the costal and transverse processs of the occipital vertebra. These subsequently unite with it, though the division can still be traced in this embryo by the arrangement of the cells in the sections.

(1) Weiss, A. Die Entwickelung der Wirbelsäule der weissen Ratte, besonders der vordersten Halswirbel. Zeitschs. f. wissenschaftl. Zool., Bd. lxix, Heft 4, 1901.
(2) Noordenbos, W. Weber die Entwickelung des Chondrocranium der Säugethiere. Petrus Camper. Deel., iii, 1905.
(3) Gaupp, E. Zur Entwickelungs geschichte und vergleichenden Morphologie des Schädels von Echidna aculeata var. typica.
(4) Froriep, A. Zur Entwickelungs geschichte der Wirbelsäule, insbesondere des atlas und Epistropheus und der Occipital region. Arch. f. Anat. and Physiol. Anat., abth. 1886.
(5) Voit, M. Das Primordial cranium des Kaninchens. Anat. Heft, v. 38, 1909.
(6) Macklin, C. C. The skull of a human fetus of 40 mm. American Jour. of Anat., vol. 16, no. 3, 1914.

31. On the relation of mitochondria to zymogen granules. J. Albert Key. Creighton Medical College, from the Department of Anatomy of the University of Chicago. (Introduced by R. R. Bensley.)*

The material used for this study was the pancreas of the toad. A number of toads were injected with pancreatic secretion or pilocarpine and the pancreas was fixed at various periods after injection. In some cases the injection was repeated at regular intervals for several days. The mitochondrial methods of Bensley, Altman, Benda, Regaud, and Kolster were used. But the best preparations were obtained by fixing in Bensley's acetic-osmic-bichromate mixture and staining with acid fuchsin

and differentiating with picric acid. For zymogen granules the pancreas was fixed in Bensley's formalin-zenker solution and stained with neutral gentian or neutral saffranin.

In the normal resting pancreas of the toad the zymogen granules crowd the portion of the cell between the nucleus and the lumen and may extend beyond the nucleus into the basal zone. The mitochondria are chiefly found in the basal zone but may extend around the nucleus into the mass of zymogen granules. When the gland is subjected to prolonged stimulation the large zymogen granules are discharged and the central zone of the cell is occupied by very minute granules having the same staining reactions as the zymogen granules. The mitochondria on the contrary are not exhausted even by prolonged stimulation, but in many cases seem to increase in length and extend to the central zone of the cell.

In both the resting and in the stimulated pancreas the mitochondria curve around the nucleus and wind through the cytoplasm with their long axes roughly parallel to that of the cell. They vary greatly in length and in diameter. Branching forms are fairly common, as are also the knobs and spindle like swellings on the filaments which have been interpreted as evidence that the mitochondria break up to form the zymogen granules. However these swellings do not stain with neutral gentian, neutral saffranin, or neutral red. Nor are they well fixed in formalin-Zenker material. By combining his neutral gentian and acid fuchsin methods Bensley is able to differentiate the mitochondria and the zymogen granules in the same proportion. I was unable by this method to detect any difference between the swellings and the rest of the filaments. Hence I concluded that they do not contain zymogen granules. Likewise the absence of reciprocal changes in the amount of mitochondria with variations in the content of zymogen granules leads me to believe that the zymogen granules are not formed directly by the mitochondria.

32. Studies in peripheral nerve regeneration. Edwin G. Kirk and Dean D. Lewis, Morris Institute of Medical Research of Michael Reese Hospital, Chicago.

Technique. Segments of the dogs' ischiadic nerve varying in length from 1 to 3 cm. were excised, fascia lata from the same dog being used to construct a tube leading from proximal to distal stump, the hiatus not being otherwise closed. Thus, regeneration following trauma may be studied without interference from various external mechanical factors. Also the comparative behavior of proximal and distal stump is more easily determined than when the ends are approximated. Present material includes 36 nerves, of which 14 are complete serial sections.

Observations. In addition to confirming the work of Ranson in almost all details, the following points were noted. The empty fascial tube early fills (first to seventy-second hour) with serum containing a few mononuclear migratory cells into which rapidly grow from the proximal stump, protoplasmic bands containing numerous neurilemmal nuclei, these being direct outgrowths of the neurilemmal sheathes. These

begin invading the serum the first two days and from that time on continuously proliferate down the tube. These protoplasmic bands are not tubular, but solid strands of cytoplasm, anastomosing frequently as a network. They constitute channels or beds along which the non-medullated fibers from the proximal stump rapidly grow,—so rapidly that often the protoplasmic bands precede the non-medullated fibers by not more than the length of one or two neurilemmablasts. The non-medullated fibers (as previously shown by others) originate a) by terminal division of the original bundles of non-medullated fibers of the proximal stump; b) by subneurilemmal division of medullated axones of the proximal stump. A gap of 1 cm. is bridged by numerous protoplasmic bands and their contained non-medullated fibers within 5 to 6 weeks—and correspondingly for larger gaps. (Above observations on Cajal-Ranson technique).

About the sixth week many of the fibers bridging the gap acquire a myelin sheathe in their upper part, i.e., that nearest the proximal stump but yet unmistakably belonging to the regenerated part. (Mallory's phosphotungstic technique.) Many of these non-medullated fibers are exceedingly minute, not more than one-tenth the diameter of a fully developed medullated fiber. At the seventh week the upper 3 or 4 mm. of the regenerated segment contains many medullated axones. At the ninth week many of the fibers bridging a gap of 12 mm. have acquired a medullation throughout this extent and even some distance into the old neurilemmal sheathes of the distal stump. All efficient regeneration of nerve fibers is from the proximal axone. All medullated nerve fibers regenerate through the gap as non-medullated ones which later acquire medullation. All medullation begins proximally and proceeds distally.

Interpretation. The myelin is laid down in situ, whether by activity of axone or by neurilemma we have not determined—but undoubtedly it appears only in those parts of the new fiber which have reached an age of 6 to 6½ weeks, hence it appears proximally first. But many of the regenerated fibers which have undoubtedly attained this age do not yet possess myelin sheathes. Presumably some of these are derivatives of the original non-medullated fibers.* [*For earlier series see Kirk and Lewis. Jour. Am. Med. Assoc. 1915. Vol. LXV. p. 486-491.]

33. The germ cell cycle in the mouse. W. B. Kirkham, Osborn Zoological Laboratory, Yale University, introduced by R. G. Harrison.

The material for this research is (1) a complete series of embryos, at about 24 hour intervals, from the fertilization of the egg to the time of birth, and (2) a complete series of gonads of both sexes, likewise representing 24 hour intervals, and covering the period from birth to 50 days old.

The primordial germ cells have not been found in embryos younger than 11 days, but from that time on their development has been traced without a break. They are characterized by having large, round nuclei, and clearly defined cell membranes, while the adjacent epithelial cells have smaller, oval nuclei, and indistinct membranes.

Mouse embryos of 11 days show the primordial germ cells scattered through a much larger number of epithelial cells, without sexual differentiation. At 13 days testes can be distinguished from ovaries by the evidence in the form of tubule formation. In male embryos of 15 days it is evident that the primordial germ cells form the cores, while epithelial cells line the inner walls of the tubules, and this arrangement assumes great significance in view of the fact that older male embryos show degeneration of the primordial germ cells, and a simultaneous increase in size, together with a rounding up of outline, on the part of the nuclei of the peripheral epithelial cells, which can now be called spermatogonia. Some of the primordial germ cells in male gonads divide after tubules are formed, but all appear sooner or later to degenerate, and about 8 days after birth none are longer visible.

The development of spermatozoa from the spermatogonia goes on at about the following rate, variations of 2 or 3 days being allowable in each case to cover individual differences: the first primary spermatocytes appear on the thirteenth day after birth; first secondary spermatocytes on the twenty-third day; first spermatids twenty-sixth day; and first spermatozoa, attached still to Sertoli cells, on the thirtieth day. Not until the thirty-eighth day after birth have spermatozoa been found in the seminal vesicles, and then in only small numbers.

No new evidence has been found as to the origin of the Sertoli cells, nor can any definite statement be made as to the time of their first appearance in the testes. In testes of 30-day old males Sertoli cells are present, and they can easily be found in any older specimens.

The female gonads during the embryonic period show, in contrast to those of the male, no degenerating cells, but instead a constant increase in size and in number (by mitosis) of the primordial germ cells. At the time of birth the largest primordial germ cells already possess a single enveloping layer of epithelial cells, and can properly be termed oogonia.

After birth the primordial germ cells of the female, or oogonia, increase still further in size, but no increase in number takes place. Many layers of epithelial cells arrange themselves around the largest oogonia, lacunae appear inside the follicles thus formed, and it would seem on the seventeenth day after birth as though ovulation was about to occur. However, instead of follicles rupturing at this early age, from about the seventeenth to the fortieth day the oogonia which have grown to full size degenerate within their follicles, the first indication being the chromatolysis of the follicle cells, which may or may not be followed by the maturation or fragmentation of the egg. In no instance has a normal maturation spindle or polar body been seen in this material.

The stimulus which causes ovulation first comes at about 40 days after birth, as the earliest ruptured follicles in this material are in ovaries from a 40-day old female, but a female of 50 days was found to contain embryos which correspond with the usual development at 12 days, while another female whose age was 48 days possessed ovaries with no ruptured follicles.

In brief this investigation shows that the sexual cycle in the mouse is completed in about 60 days, but that the male and female germ cells come from different cell lines, the oogonia being direct descendants of primordial germ cells, while the spermatogonia arise, not from primordial germ cells, but from what appear to be epithelial cells.

34. The prolonged gestation period in nursing mice. W. B. KIRKHAM, Osborn Zoological Laboratory, Yale University, introduced by R. G. Harrison.

This is an embryological investigation of the discovery published by Prof. J. F. Daniel in 1910 that among mice, nursing females if again fertilized give birth to a new litter only after a longer gestation period than that of non-nursing females. He further stated that the delay in parturition was equivalent to approximately one day for each young mouse nursed.

Two series of embryos have been studied, one taken from nursing, the other from non-nursing females. Both series are spaced at 24 hour intervals, and cover the period from the fertilization of the eggs to the time of birth.

The differential characteristics of each day's development having been determined in the series from non-nursing females, a comparison with the nursing series shows the following facts:

(a) Ovulation and fertilization, when they occur, occur at the same time relative to parturition,—namely the following night,—in both nursing and non-nursing females, although nursing females are much less liable to ovulate.

(b) Segmentation of the fertilized eggs and their passage down the Fallopian tubes take place at the same rate in both nursing and non-nursing females, resulting in blastulae in the lumen of the uterus on the fourth day.

(c) Implantation occurs in non-nursing females during the fourth day, while in nursing females implantation does not take place until the close of the twelfth day. This delay would appear to be connected with the fact that up to this time the nursing young are obta ning all or most of their nourishment from the females.

(d) The stages following implantation show progressive development in non-nursing females, but in nursing animals the time elapsed since fertilization bears no fixed relation to the stage of development of the embryos, nor does this appear to be associated with the number nursing nor with the total number of embryos. It can be stated, however, that almost every set of embryos examined is behind the stage of development it should have reached if growth and differentiation at the rate of embryos in non-nursing animals were to bring about birth at the date set by Daniel's formula, a day's delay for each one nursing.

The prolongation of the gestation period in nursing mice is therefore largely due to delayed implantation.

35. On the Mesenterium commune of human embryos. (Lantern.) FREDERIC T. LEWIS, Harvard Medical School and JAMES W. PAPEZ, Atlanta Medical College. (Presented by Professor Papez.)

In order to obtain a clearer insight into the factors involved in the primary rotation of the intestinal loop, a series of models has been made, showing the mesentery of human embryos *in situ*. Although a satisfactory mechanical explanation of the intestinal rotation has not been found, and the work is still incomplete, the models are perhaps of sufficient interest to justify their description. Since in the adult the mesentery is usually displayed by cutting away the intestinal tube along its attached margin, the same method was followed in preparing the models.

In the youngest specimen—the Bremer embryo—the mesentery is straight and uninterrupted from the anterior end of the mediastinum to the posterior end of the mesorectum, being comparable with the mesentery of a fish. The large pair of vitelline veins and the several small pairs of vitelline arteries, together with the pneumatoenteric recesses, are essentially bilaterally symmetrical. (The recesses in this embryo have been previously described before this Association, in connection with a demonstration that tracheo-oesophageal fistula is due to a division of the fore-gut along their dorsal margins—Lewis, 1912.)

A slight but distinct bending of the mesentery is seen in the 4.9 mm. Begg embryo. The mesogastrium deviates toward the left, and the small remnant of the left pneumato-enteric recess has been displaced forward so that it does not appear in the model. The left vitelline vein enters the mesentery a little lower than the right. The mesentery is slightly drawn out toward the yolk-stalk, with its mesenteric arteries still symmetrically placed on either side. There is possibly a slight suggestion of intestinal rotation in the normal direction.

In a 7.5 mm. specimen, the mesogastrium bulges conspicuously to the left; the left vitelline vein courses upward into the right, making a straight channel, without, however, deflecting the duodenum to any appreciable extent. The prolongation of the mesentery toward the yolk-stalk has increased, and the vitelline artery on its left side has disappeared. The intestinal loop shows a slight but distinct indication of sagging downward on the right side of the right vitelline artery, and intestinal rotation has therefore begun.

In a 9.4 mm. embryo, remarkable for the precocious disappearance of that part of the vitelline veins which leaves the mesentery and crosses the abdominal cavity, the intestinal rotation is well established. The stomach swings boldly to the left and it appears that the intestine is carried to the right by a compensatory bend of the elongating epithelial tube. We are inclined at present to regard the gastric and intestinal bends together as forming an 'S,' comparable with those secondary S-shaped bends which soon develop in the intestinal mesentery itself. Accordingly we ascribe the rotation of the intestinal loop to the growth of its epithelial portion, and not to the influence of adjacent blood vessels.

Although the loop of intestine appears to drop over the taut mesenteric artery, as if the position of that vessel on the right of the intestine were an essential factor in rotation, this possibility has been eliminated. For in one of the embryos modelled, there is a normal disposition of the mesentery, although the artery anomalously persists on the left side. Professor Frazer and Dr. Robbins, in the last issue of the Journal of Anatomy and Physiology (October, 1915) suggest that the persistence of the left umbilical vein and its shifting to the median line are the cause of the intestinal rotation. This is a very ingenious suggestion, illustrated by an interesting schematic figure. If it is correct the rare cases of reversed torsion should show an umbilical fissure on the right side of the gall bladder. In Strehl's case of reversed torsion, unfortunately nothing is said of the liver, but such an abnormality, had it existed, could hardly have escaped attention. We are inclined, therefore, to reject the tempting suggestion, but propose to give it more careful consideration in continuing this work.

See 64 P. E. Lineback, page 262.

86. Anomaly in the circle of Willis, due to absence of the right internal carotid artery. Lawson G. Lowrey, Harvard Medical School. No. 59 Danvers State Hospital. Hospital Papers.

Anomalies in the formation of the circle of willis are, in my experience, relatively common, but are usually found in the posterior communicating arteries or in the origin of the posterior cerebral arteries. The case here reported is the only one known to me in which the internal carotid artery was missing. The possibility of this anomaly is not mentioned in any of the standard text-books of anatomy, and a hasty search through the available literature has revealed no other reported case.

The condition was found in a woman 75 years of age autopsied by me at this hospital. No other vascular anomalies were found. The right carotid trunk arose as usual from the innominate, and measured 4 mm. in diameter. The left arose from the aortic arch, and measured 7 mm. in diameter. Both vessels were traced to the level of the palate and no anomaly of distribution was noted beyond the absence of any trace of the internal carotid branch of the right trunk. No bony canal was found in the petrous portion of the right temporal bone. The left vertebral artery was of unusual size.

The basilar artery divided into two branches of unequal size. The larger, right branch passed forward in the usual position of the posterior communicating artery and turned laterally into the Sylvian fossa, forming the middle cerebral artery. From the upper surface, the posterior cerebral artery passed backward. Both anterior cerebral arteries arose from the left internal carotid which was otherwise normal in its distribution. The right anterior cerebral, arising from the left internal carotid artery, was joined by a very fine twig from the right middle cerebral artery. The right ophthalmic artery arose from the anomalous middle cerebral.

Absence of the internal carotid seems chiefly interesting because of the great rarity of the anomaly and because of the functionally efficient rearrangement of vessels. It means, of course, either complete atrophy or agenesia of the third aortic arch and all of the distal portion of the primitive dorsal aorta on the right side.

37. Experimental confirmation of the view that lymphatic endothelium arises in loco from intraembryonic mesenchymal cells and that it is not derived from the endothelium of the veins. CHARLES F. W. MCCLURE. Princeton University.

"Does the endothelium of the lymphatic system arise, at any time or place, in a discontinuous manner and independently of that of the veins? As we shall see the determination of this question constitutes a solution of the lymphatic problem."

The above question forms the opening sentence of a recent paper by the writer,[1] a question which he is now able to answer in an affirmative manner on evidence obtained by experimental means.

The investigations of Loeb,[2] and later those of Stockard,[3] have shown that teleost embryos when subjected to the influence of certain chemical agents often develop without a circulation. Stockard has shown in particular that the development of the blood-vascular system of these embryos may be arrested in such a manner that the arteries and veins are represented by a series of independent and discontinuous anlagen and that the endothelium of these vascular anlagen is formed in loco from mesenchymal cells. These experiments of Stockard, together with those of Hahn,[4] Miller and McWhorter,[5] Reagan,[6] Werber,[7] and Reagan and Thorington,[8] substantiate completely the observations of Rückert and Mollier,[9] Felix,[10] Schulte[11] and others regarding the local origin of intraembryonic haemal endothelium from mesenchymal cells. The 'ingrowth' or 'angioblast' theory of His, hitherto so vigorously exploited by a certain group of American anatomists is now, therefore, merely of historic interest.

It has occurred to the writer if the development of the blood-vascular system can be arrested by experimental means at an early on-

[1] Anat. Rec., vol. 9, no. 7, 1915.

[2] Plüger's Archiv, Bd. 54, 1893, and Pop. Sci. Monthly, vol. 80, 1912.

[3] Proc. Amer. Ass. Anat., Anat. Rec., vol. 9, no. 1, 1915 and Amer. Jour. Anat., vol. 18, no. 2, 1915.

[4] Archiv Entwickmech., Bd. 27, 1909.

[5] Anat. Rec., vol. 8, 1914.

[6] Anat. Rec., vol. 9, no. 4, 1915 and Anat. Rec., vol. 10, no. 8, 1915.

[7] Anat. Rec., vol. 9, no. 7, 1915.

[8] Anat. Rec., vol. 10, no. 8, 1915.

[9] Hertwig's Entwickelungslehre d. Wirbeltiere, Bd. 1, erste Teil, zweite hälfte, 1906.

[10] Anat. Hefte, Bd. 8, 1897.

[11] Memoirs of the Wistar Institute of Anatomy and Biology, no. 3, 1914.

togenetic stage, that the lymphatic system might be influenced in a similar manner. If one could find an undoubted instance of a chemically treated embryo in which a circulation has not been established and in which the arteries and veins, as well as the lymphatics, were found to consist of a series of discontinuous and independent anlagen, it would seem to be positive proof that the endothelium of the lymphatics, like that of the arteries and veins, has been formed in loco from mesenchyme and that it had not been derived from the endothelium of the veins. As far as the subocular lymph sacs of a teleost embryo are concerned, the writer now has such experimental evidence at hand.

In the spring of 1915 the writer subjected the early cleavage stages of the Chub Sucker (Erimyzon sucetta oblongus, Mitchill) to the influence of weak solutions of KCN[12] and in many cases the embryos developed without a circulation. As described by Stockard for Fundulus, these embryos developed a string-like heart, in some cases solid and without a lumen, and possessed a greatly expanded pericardial chamber filled with fluid. Free erythrocytes could often be seen floating in the pericardial chamber and in some cases the pressure of the fluid became so great that the walls of the pericardial chamber burst. Reconstructions of a number of these oedematous embryos with solid string-like hearts were made, after the method of Born, of all the definite endothelial-lined vascular anlagen that could be observed under a high magnification, and I can verify the recent observation of Stockard[13] that the aorta and cardinal veins of the teleost embryo, as I have found to be the case for the main lymphatics,[14] do not develop from a plexus. Most of the reconstructions made by the writer were confined to the region contiguous to and anterior to the cardino-Cuvierian junction. In one of the embryos reconstructed (Princeton Embryological Collection, 1020) a continuous system of vascular lumina for the aorta and cardinal veins had not yet been established in the region anterior to the cardino-Cuvierian junction nor, as a matter of fact, in the more caudally situated portion of the body. In the region anterior to the cardino-Cuvierian junction, the lumina of the aorta and its branches and those of the precardinal veins were represented by a series of independent and discontinuous endothelial-lined vascular spaces, the precardinal veins being represented by eleven and the aorta and its branches by eight of these vascular spaces. *Near the caudal end of each eye and just anterior to the independent anlage of the hyoidean artery, which was present on both sides of the embryo, an entirely independent endothelial-lined subocular lymph sac was found to be present.* The relatively large size, and the location of this sac near the caudal end of the eye and just

[12] 1 cc. of a 1 per cent solution of KCN in 450 cc. of water. The embryo especially referred to in this paper was treated with KCN on April 26 for 18 hours and killed on May 13.

[13] Amer. Jour. Anat., vol. 18, no. 3, 1915.

[14] Memoirs of the Wistar Institute of Anatomy and Biology, no. 4, 1915.

anterior to the hyoidean artery, leaves no doubt regarding its character. The most anterior of the independent and discontinuous anlagen of the precardinal veins which were present in this embryo were found opposite the cranial end of the otocyst, a point which lies a considerable distance from the anlagen of the subocular lymph sacs. As no veins or endothelial-lined independent anlagen of the veins are found in the vicinity of these sacs, their endothelium, like that of the independent anlagen of the arteries and veins, must have been formed in loco from mesenchyme.

The study of a number of reconstructions of chemically treated embryos leads me to believe that the aorta is the first of the main blood-vascular channels to establish a continuous lumen and that the continuous lumina of the veins is first established near the caudal end of the otocyst and in the vicinity of the cardino-Cuvierian junction.

Those investigators who have followed the development of vascular channels solely by the aid of injections seem to have overlooked the fact that they are not studying the genesis of the endothelium, but rather the topographical arrangement of the vessels after a circulation has been established. Otherwise it would not be possible to inject them. After the main arterial and venous channels have been formed and capillary plexuses established, the picture naturally becomes more complicated. It is from this stage of development, however, that the injectionist necessarily draws his conclusions.

It has already been pointed out by the writer[15] that the failure of the independent anlagen (lymph vesicles) of the main lymphatic channels to undergo concrescence and form continuous vessels which connect with the veins, would result in an oedematous condition of the embryonic body. It is evident that the oedematous condition presented by these chemically treated teleost embryos must be due to some analogous cause. During the early stages of ontogeny and before a haemal circulation has been formed, there must necessarily be a gradual increase in the amount of fluid which collects in the tissue spaces of the embryo. In the course of normal development the process of concrescence between the independent anlagen of the haemal vessels adjusts itself to the demands of fluid production so that a circulation is established and an oedematous condition of the body does not occur. When, however, as shown by experiment, the normal process of concrescence between the independent and discontinuous anlagen of the main haemal vessels has been experimentally delayed, without a corresponding arrest of fluid production, a circulation is not established, and an oedematous condition of the body naturally prevails.

[15] Anat. Rec., vol. 9, no. 4, 1915

38. Binucleate and multinucleate cells in tissue cultures. C. C. MACKLIN, Department of Anatomy, Johns Hopkins Medical School.

The problem of the origin and fate of the binucleate and multinucleate cells found in cultures from embryonic chick tissue, growing in vitro in modified saline solution, was investigated by the method of continuous observation of the living cell, supplemented by a study of these cells in fixed preparations of tissue cultures.

It has been concluded from this research that such nuclei arise by direct division. Nuclear amitosis consists apparently in a constriction of the elongated nucleus, rather than in the formation within the nucleus of an equatorial plate, which subsequently splits. In this process of nuclear division it is believed that the centrosphere and mitochondria may play a part. It is further believed that multinucleate cells arise by a repetition of this process.

The fate of the binucleate cell has been similarly investigated, and in no case has it been found that the parts became separated to form the nuclei of mononucleate cells. On the contrary the only change which took place in such cells occurred when they were undergoing mitosis. In such a case the changes in the binucleate cell were essentially the same as those characteristic of mitosis in the mononucleate cell. There was a disappearance of the nuclear membrane with a fusion of the karyoplasm of the two nucelar moieties and the formation of a single amphiaster. In this way there finally resulted two apparently normal daughter nuclei, contained within separate cells.

A double-nucleated cell was followed for almost twelve hours continuously, and the entire process of mitosis, with fusion of the two nuclear parts, was seen to occur in it, finally culminating in two new separate cells. Fusing nuclei undergoing mitosis were found in fixed preparations.

Nuclei in tissue cultures have been found in which the spireme has formed while the nucleus was bent upon itself, apparently undergoing amitotic division. This superposition of mitosis upon amitosis, combined with the failure of the latter process ever to result in the formation of separate new cells, would seem to indicate that amitosis, in the material examined, is a change in form of the nucleus rather than a method of cell proliferation.

39. A plea for the more critical study of the intimate structure of the cerebral cortex as furnishing the probable anatomical basis of mental development. E. LINDON MELLUS, Brookline, Mass.

In connection with the paper charts will be shown of various areas of the cortex x ca. 1200.

It has been objected that to go over the whole cortex in this way would require so long a time as to make it doubtful of accomplishment, but it is contended that such charts give so good an idea of the intimate structure as to justify the work. Other surveys discussed and compared.

The lamination of the various areas is discussed, and the reason

given for adopting Meynert's scheme of five layers as the division most likely to be ultimately accepted.

The suggestion is made that as a cortical cell develops it becomes invested with more and more protoplasm, that many of the cortical cells are still largely undeveloped, and are perhaps incapable of function. But little is really known today of the function of the innumerable cells in the various layers. The giant cells of the so-called motor area are the only cells of which anything definite can be asserted. Various areas are known as the areas of special sense, but the facts yielded by pathology and animal experimentation are misty, and often openly contradicted by good authorities.

40. A study of the hypophysis of the pig.[1] M. M. Miller. Department of Anatomy, Vanderbilt University Medical School.

This paper is limited to the embryology (origin and development), the morphological significance, and the histological structure of the hypophysis cerebri of the pig.

Material and Methods. The major part of the material used in this study may be found in the Harvard Embryological Collection. It consists of pig embryos, ranging in size from 3.1 mm. to 45 mm. The hypophyses of new-born and full grown pigs were also used.

Wax reconstructions were made of many of the younger specimens. High power studies of sections stained with Biondi's stain and other granular stains furnished the histological observations.

Embryology. In the younger specimens the oral plate was intact and the anterior end of the notochord was attached to the pharyngeal wall. The hypophyseal angle was present. As the development proceeds, Rathke's pouch appears as an evagination from the pre-oral epithelium (ectoderm), the notochord pulls away from the pharynx carrying with it a mass of cells (entoderm) which at first lies in relation to the apex of Rathke's pouch. Later these cells enter into the structure of the pharyngeal wall of the pouch, gradually shifting their position from the apex of the pouch to the constricted neck (stalk) of the hypophyseal sac. This change in position is brought about by the relatively more rapid growth of the wall of this pouch nearest the brain tube. The notochord retains its connection to the pharyngeal wall of Rathke's pouch until after the 15 mm. stage. The infundibulum first appears in the 10 mm. stage. After the hypophyseal sac becomes separated from the pharynx, it undergoes a rotation anteriorly and superiorly which is brought about by the growth of the infundibulum and surrounding structures. Consequently the mass of cells which was in relation to the notochord and hypophyseal stalk is carried forwards and upwards. The lateral cords grow around and encapsulate this mass of cells until in the new-born it is situated within the glandular portion, anterior to the ventricle, and forms the medulla of the anterior lobe.

[1] Accepted by the Harvard Medical School is a thesis that partly fulfilled the requirements for the degree of Doctor of Philosophy.

These cells are considered to be of entodermal origin (1) on account of their close relation to the notochord, (2) the difference in the arrangement of these cells from those of the cortex of the anterior lobe, which developed from the lateral cords, (3) and the microscopical structure of the medullary part of the anterior lobe of the functioning hypophysis.

Morphology. The observations on the developing hypophysis of the pig tend to support Küpffer's idea that the relationship between the mouth, intestine, and brain (infundibulum) is significant of an ancestral communication between the neural tube and intestine. The perforation in the superior free stump of the oral plate, observed in the younger embryos studied, is indicative of a communication between the intestine and Rathke's pouch. This is considered as the remains of the old mouth (Palaestoma) as described by Küpffer in his schematic ancestral vertebrate. The small mass of entodermal cells which are attached to the anterior end of the notochord is comparable to the subneural gland as described in Ascidians.

Histology. If the hypophysis is considered as having a three fold origin, the histological structure becomes relatively simple.

The glandular portion (anterior and intermediate lobes) is composed of two distinctly different types of cells, those which have a marked affinity for acid stains and stain deeply (chromophiles), and those which stain less intensely and are decolorized by the ordinary staining methods (chromophobes).

The chromophiles form the greater part of the medulla of the anterior lobe. They vary greatly in appearance, depending upon the stage of the functional activity. These cells are arranged in rather definite acini.

The chromophobes predominate in the cortical portion of the anterior lobe and the intermediate lobe. These two lobes are continuous with each other around the ventricle. These cells do not exhibit the regular arrangement found in the medullary part of the anterior lobe. The spindle-shaped supporting cells and colloidal vesicles are other interesting structures in the intermediate lobe.

The posterior lobe (infundibulum) consists mainly of tissue of a fibroglia character and a small amount of white fibrous connective tissue.

Conclusions. Sufficient evidence is presented, in the above investigation of the hypophysis cerebri of the pig, to warrant the following conclusions:

1. That the hypophysis in the pig develops in a different way from that heretofore described in any of the mammalian types.

2. That the entoderm, as well as the ectoderm, enters into this structure. This is in accordance with the development of the hypophysis in birds and lower forms.

3. That this ectoderm comes from two sources, the brain wall and the oral cavity; and that the entoderm is derived from the fore-gut.

4. That the notochord takes an important part in the development of the hypophysis. First, it plays a mechanical rôle in pulling out the diverticulum of the entoderm over the hypophyseal angle; and secondly,

its anterior extremity is in intimate relation with the entoderm from the fore-gut which enters into the structure of the hypophysis.

5. That the anterior lobe contains two distinct portions, a medullary part which is of entodermal origin, and a cortical layer which is developed along with the intermediate lobe from the ectoderm which formed Rathke's pouch.

6. That the results here obtained strengthen the theory that the glandular portion of the hypophysis is phylogenetically homologous with the sub-cerebral gland of Ascidians.

7. That the explanation of the development of the hypophysis here presented explains the presence of two distinct types of cells found in the anterior lobe of the hypophysis.

41. Artificial parthenogenesis in Cumingia. MARGARET MORRIS, Osborn Zoological Laboratory, Yale University. (Introduced by R. G. Harrison.)

The eggs of the mollusc Cumingia tellionoides can be made to develop parthenogenetically by the use of heat followed by hypertonic sea-water. Some of the eggs so treated form polar bodies in a normal manner, but others pass at once to a two-cell stage without undergoing maturation. Experiments were made which show that the eggs in which maturation has been suppressed may develop to fairly normal cellular larvae, while those which have formed polar bodies do not do so.

It is seen from a study of preserved material that in some eggs the chromosomes of the first maturation spindle divide normally giving rise to two daughter nuclei which are both retained in the egg, which has, therefore, the full amount of chromatin. The cytological study of the later stages of these eggs has not yet been completed, but it seems certain that they give rise to the swimming larvae.

42. Histological changes in testes following vasectomy. BURTON D. MYERS, Indiana University School of Medicine.*

Sterilization is suggested as one of the methods to be used in checking increase in the number of defectives. Indiana has a law providing for sterilization under certain circumstances. and other states have attempted such legislation. Therefore, it becomes desirable to know what changes occur in the testis after cutting or ligating the ductus deferens.

Though I have been in touch with the proper officials in Indiana for several years with the hope of being able to report on changes in testes of some of the six hundred individuals on whom a vasectomy was performed, no opportunity has as yet arisen for such an examination.

My report is, therefore, confined to the histological changes occurring in the testes of a series of white rats following ligation of the ductus deferens on each side.[1] The operated rats were permitted to live ninety

[1] About two years ago I expressed to Dr. Henry H. Donaldson my intention to do the work here reported. He offered to furnish material as he had a series of white rats with double ligation of vas, for another problem. I desire to express my appreciation of this assistance.

to one hundred and twenty days after the operation, an equivalent of seven and one-half to ten years for man. The testes were fixed in Zenker's and Flemming's fluid. Several stains were used, the best result being secured with iron hematoxylin.

Before reporting the results of this operation permit me to recall the fact that in addition to the seminiferous tubules with their spermatogenetic cells, the products of which are eliminated through the ductus deferens, the testicle has also an internal secretion. The cells responsible for this internal secretion, 'interstitial cells,' as the name implies, lie in the intervals between the seminiferous tubules. Though these cells were first described in 1850 it was not until 1897 that a discussion of their function was undertaken, a discussion which later investigation failed to verify. The experimental work of Steinach 1910, 1912, and 1913, established almost beyond question the function of these interstitial cells as controlling sex impulse and secondary sex characteristics.

On sectioning the series of testes of the operated rats, I find that the testes of those animals which had been permitted to live ninety days after operation show a high degree of disintegration of spermatogenetic cells. The interstitial cells on the contrary are entirely unaffected. In the animals in which 120 days had elapsed between operation and date when killed, most seminiferous tubules are entirely free, as mere connected tissue capsules containing a slight amount of debris. In some seminiferous tubules a few spermatogonia can still be discerned at the periphery, beneath the capsule, all other spermatogenetic elements have undergone complete degeneration and absorption. The interstitial cells on the contrary show no degenerative changes. Their number seems to be increased. This is not, however, the case, the appearance of an increase being due in part to the fact that they, instead of the seminiferous tubules, are now the conspicuous elements of each microscopic field; and in part to the fact that they are crowded somewhat more closely together than normal as a result of a slight shrinkage following the disintegration of the seminiferous tubules.

Therefore, as a result of vasectomy, or was ligation, we are able to say with much certainty that the sterilization of the individual is accomplished without in any way disturbing the internal secretion of the testicle. The psychic life and secondary sex characteristics are therefore entirely unaffected. There is nothing about the operation that will make the individual in any way a freak. He will not acquire a falsetto voice, nor will he lose any secondary sex characteristic. These conclusions are verified by observation of men upon whom this operation has been performed.

The result indeed is exactly comparable to that which follows a high urethritis with occlusion of the lumen of the ductus deferens. Therefore, why should not the state provide deliberately for a condition many acquire as the result of disease?

43. Growth and distribution of the milk-ducts and development of the nipple in the albino rat from birth to ten weeks of age. (*Lantern slides.*) J. S. Myers, Institute of Anatomy, University of Minnesota, Minneapolis. (Presented by C. M. Jackson.)

Observations made on 100 rats show the number of glands varies between 10 and 13, the normal number being 12 (6 pairs). Only one supernumerary gland was observed. The second thoracic glands are those most often absent.

Only one primary duct is present in each gland. This duct after reaching the tela subcutanea turns at right angles and pursues a course parallel to the surface of the skin. The majority of the branches of ducts belonging to the first thoracic gland lie cephalad to the nipple, while those from the second and third thoracic glands lie latero-cephalad to the nipple. In case of the abdominal and first inguinal glands the greater number of ducts lie latero-caudad to the nipples, while in the last inguinal the ducts lie caudad to the nipples. The dichotomous method of branching frequently occurs, especially in the proximal branches.

Reconstructions and cleared preparations show that anastomoses sometimes occur between the ducts of a single gland. It is uncertain whether anastomoses occur between the ducts of different glands.

End-buds are present on a large number of terminal ducts at all stages studied. No true alveoli were observed. Large numbers of lateral buds are present on the sides of all ducts distal to the primary duct during the earlier stages. Such lateral buds later develop into branches of the ducts.

Considerable individual variation in the development of the glands was noticed. Not only do the corresponding glands of opposite sides differ in their degree of development, but also the glands of one individual may be better developed than those of another even several days older.

The characteristic distribution and ramification of the ducts apparently depend upon the space available for their growth.

The growth and branching of the ducts goes on at an unusually rapid rate about the ninth week, probably corresponding to the age of puberty.

A distinct lumen is present at birth in all ducts distal to the intra-epidermal portion of the primary duct. At the end of the second week the lumen extends to the surface of the nipple.

The periphery of the nipple area is marked by a hood-like epithelial ingrowth. The nipples make the most rapid growth during the second week, toward the end of which time they are very conspicuous.

44. Neuromeres and metameres. H. V. Neal, Tufts College.*

The neuromeres of vertebrate embryos have been regarded as important evidence of the primitive metamerism of the body and as decisive criteria of the number of metameres in the head region. The hind-brain neuromeres or 'rhombomeres' appear to be metameric struc-

tures, since they correspond numerically with the mesodermic somites, since they seem directly connected with the metameric visceral arches, and since as local thickenings of the medulla they are inexplicable as results of mechanical bending.

Graeper ('13), however, by the use of improved neurological methods upon mammalian embryos finds the relations of the rhombomeres to the visceral arches not so clearly metameric as has been assumed. Using the same methods upon Squalus embryos the writer has been able to obtain results essentially similar to those of Graeper. These are summarized in the present paper.

In embryos of Squalus the motor nidulus of the Trigeminus lies in the second and third rhombomere; that of the facialis nerve extends through four neuromeres, viz., the fourth, fifth, sixth and seventh. The nidulus of the glossopharyngeus lies in the sixth and seventh rhombomeres, and that of the vagus extends from the seventh into the unsegmented portion of the medulla posterior to the seventh.

Of the somatic motor nerves, the oculomotorius has its nidulus in the midbrain. That of the trochlearis lies primarily wholly in the first (cerebellar) rhombomere. In later stages, however, some of the trochlearis fibers come from the midbrain and the niduli of the oculomotorius and trochlearis overlap each other. While, according to Graeper, the nidulus of the abducens nerve in mammal embryos lies in the fifth rhombomere, in Squalus it extends through the sixth, and the nerve receives some fibers from neuroblasts in the fifth and seventh rhombomeres. The hypoglossus has an extended nidulus in the unsegmented region posterior to the seventh rhombomere.

Primarily the somatic motor niduli lie dorsal and lateral to the splanchnic motor niduli just as in mammal embryos (Graeper). As a consequence of this relation the fibers of splanchnic motor and somatic motor nerves cross within the wall of the medulla. These relations are seen with special clearness in the region of the roots of the vagus and of the hypoglossus nerves. The distinction commonly made between lateral and median niduli, therefore, is based upon secondary and not upon primary relationships.

It is difficult to reconcile the present relations of the rhombomeres to motor nerves with any scheme of primitive metamerism. The writer ('14) has attempted in an earlier paper to interpret the present relations of the somatic motor nerves to the neuromeres upon the assumption that their relations were primarily metameric. But such an interpretation is more difficult in the case of the splanchnic motor nerves. Assuming, however, that a single rhombomere was originally connected with a single visceral arch by a splanchnic motor nerve, it is possible to explain the present relations of the trigeminal nerve to two rhombomeres by assuming the disappearance of a gill-cleft anterior to the spiracular cleft. This assumption has often been made and there is good reason to believe that the lost pair of gill-pouches is represented today by the club-shaped gland of Amphioxus.

A more complex problem is presented by the relations of rhombo-

meres four to seven. All four of them send fibers into the hyoid arch, while at the same time one of them—the seventh—sends fibers into three visceral arches, viz., the second, third, and fourth. The difficulty of solving the problem of these confused metameric relations is lessened of course by our knowledge that nerves become connected with their terminal organs by a process of free outgrowth, consequently permitting the possibility of changed metameric relations under changing conditions. The growth and enlargement of the ear might affect nerve relations in the region of these four neuromeres, but such a change will not explain the growth of post-otic fibers into the pre-otic region. In Amphioxus the nerves of the four metameres homologous with those to which rhombomeres four to seven belong form a plexus on the velum. Consequently there is reason to believe that in the ancestors of Craniotes metameric relations in this region of the body were modified even before the ear made its appearance.

However, the fact remains that the nerve relations of the rhombomeres—the neuromeres considered of the least doubtful metameric value—are difficult to reconcile with the assumption of a primitive metamerism. Consequently, as criteria of the primitive metamerism of the vertebrate head they do not appear as reliable as the mesodermic somites. Indeed, in the light of the facts presented in this paper it would seem that the strongest proof of the metameric value of neuromeres consists, as maintained by the writer ('96, '98), in their numerical correspondence with the mesodermic somites.

45. Some phases of cell mechanics. THEOPHILUS S. PAINTER, Osborn Zoological Laboratory, Yale University. (Introduced by R. G. Harrison.)

In a series of studies an attempt is being made to analyze some of the forces at play within the cell, along the general lines begun by Boveri and by Wilson. The material used has been the sea urchin egg and the method of approach has been: first, to produce monasters in the eggs and then to follow, in the living and in the sectioned egg, the changes through which the single aster goes. Second, to treat the eggs with narcotics such as will inhibit the cytoplasmic radiations and then to follow the centrosomes, chromosomes, etc., in their behavior. Several points of general interest will be touched upon here.

1. Under certain conditions, "spiral asters" appear in the monaster eggs. The conclusion reached after a detailed study of eggs of this type is, that the bending of the aster fibers is brought about by movements in the cytoplasm lying outside of the centrosphere. This interpretation gives a satisfactory explanation for the spiral asters observed by various workers, in Nemerteans, Annelids, Molluscs, and in Vertebrates. A second conclusion, drawn from the study of spiral asters is, that the shifting of the spindle observed in eggs, especially during polar body formation, is due to movements in the cytoplasm.

2. Observations on the living monaster eggs has shown that when the aster retreats to one side of the egg (as in normal divisions) there

is a flow of the superficial protoplasm towards the opposite side of the egg. Thus, in Arbacia, nearly all of the pigment is swept to one pole, the side opposite the aster. Bütschli attributed great importance to this movement in cell division.

3. When eggs are treated with chemicals which suppress the cytoplasmic radiations, a spindle is formed within the boundary of the nucleus, the chromosomes divide and the centrosomes separate. Cytoplasmic division, however, does not follow. Thus it is clear that the cytoplasmic radiations do not pull the centrosomes apart, as has been thought by many workers. They are probably concerned with cytoplasmic cleavage.

46. The use of a graph in teaching embryology. A. G. Pohlman, St. Louis University.

It may be that this method of graphing results is by no means a new thing in the teaching of embryology. The general idea is an up-and-down method of noting the data obtained through the study of serial section. The student is supplied with two pig series of 12 and 16 mm. The first cut in paraffin at 25 and the second cut cleared (Gage-Fish method) in celloidin cut at 50. The student dots every fourth section in the first series and every other one in the second; giving 100 micron intervals. Next the ordinary cross section paper is taken and a line drawn across the page to represent the first dot in the first slide; allow one space for each dot on the slide and then rule through the next line to show dot one on slide 2, etc. These lines are two mm. apart and therefore the relative positions of organs and parts may be studied x 20. The following structures are represented by up-and-down lines indicating their position in the series: the extent of brain; spinal cord; spinal ganglia; the olfactory area; the eye and lacrimal duct; the hypophysis; the ganglia of the Vth.; VIIth, VIIIth, IXth and Xth nerves; the extent of the membranous labyrinth; the chorda; the œsophagus; the stomach; the foldings of the small and large intestine and the anal region; the umbilical and sup. mesenteric arteries; the dorsal aorta and branchial arches on the left; the aortic-pulmonary and auriculo-ventricular valves; the foramen ovale and the pulmonary artery; the trachea and bronchi; the extent of the two lungs; the thymus and thyreoid glands; the heart; liver; bile duct including gall; the pancreas; spleen; the extent of the Wolffian body and duct; the kidney and ureter; the bladder and allantois; the sex glands; adrenal.

I have found this method of indicating that the various parts are located in certain sections of a series and that they extend through a given number of sections is easily grasped by the average student and more easily checked by the instructor. When the graph of a given part has been O. K'ed it may readily be transferred to a final graph. I show herewith the graphs of an 8, a 12 and a 16 mm. pig. The great disadvantage in the method is that the usual way of giving the embryology course should be reversed and that the text book must be used almost entirely as a collateral reading. What the student learns is a general developmental picture rather than a series of isolated facts.

It is perfectly possible to do a rough profile reconstruction by projecting selected sections x 20 on the graph paper but this is neither desirable nor expedient.

47. An experimental study of bone growth in the dog. J. L. POTTORF, Anatomical Department of the University of Missouri. (Introduced by E. R. Clark.)*

The object of this investigation was to analyze the extent to which bone growth is regulated by the mechanical factors of stress and strain. The results of the two experiments which have been carried out thus far appear to be sufficiently definite to be worth reporting.

The first experiment consisted in the binding up of the left leg of a puppy about three weeks old. The weight of the fore-part of the body was thereby thrown on the right fore-leg and the left leg was freed of all stress and strain except that resulting from the muscle pull. The animal was allowed to live twenty days. Marked differences were found in the two humeri; particularly in the thickness of the compacta, and the size of the epiphyses. The bones were split longitudinally in approximately the same plane. The thickness of the anterior side of the humerus from the unbound leg is, on the average, about 50 per cent greater than that of the bound leg. The epiphyseal ossifications of the unbound leg are noticeably larger than those of the bound leg. The two humeri are of about the same length.

A second experiment was carried out as follows: Two ten day old puppies from the same litter were used. One was killed at the beginning of the experiment, and served as a control. On the second, an operation was performed, with as nearly aseptic technic as possible, in which all the nerves of the right brachial plexus were cut, in order to eliminate all muscle pull from the fore leg, and the leg was put up in a loose sling. The animal was killed after 20 days. During this time the weight increased from 3.75 pounds to 8.5 pounds.

Some of the more striking results are as follows:

The increase in length of the entire humerus was nearly as great on the operated as on the unoperated side. Thus, while the length of the humerus in the control animal was 5.08 cm., the length of the humerus on the operated and unoperated sides were 6.2 and 6.3 cm. respectively.

In thickness, however, there was a marked difference in the two humeri. The bones were split longitudinally in as nearly the same plane as possible, and measurements made of the thickness of the compacta at corresponding points of both the anterior and posterior sides of the shaft. In the humerus from the operated side, the thickness of both the anterior and the posterior sides was 0.5 mm.; in the humerus from the unoperated leg, the thickness of the anterior side measured 2.0 mm., of the posterior side, 0.83 mm. Thus the thickness of the bone on the unoperated side exceeded that on the operated side by from 66 to 300 per cent. (It is interesting to note that, in the humerus from the control animal, the thickness of the shaft is greater even

than that of the humerus from the unoperated leg. There is evidently, then, a reduction, normally, in the thickness of the humerus during this period of growth.)

In addition to the greater thickness of the shaft attained by the humerus from the unoperated leg, this bone is larger in several particulars; its has a larger diameter: 0.8 mm. as compared with 0.7 mm. (antero-post. diameter at about the middle of the shaft); the epiphyseal cartilages are wider, and the epiphyseal ossification centers are slightly larger. It is of interest, however, that the epiphyseal ossification in the head of the humerus from the operated leg is much larger than that of the control humerus (11 x 5 mm., as compared with 8 x 3 mm. in longitudinal section), and that, whereas in the longitudinal section of the control no ossification center is visible in the lower end of the bone, there is present, in the lower end of the humerus from the operated leg, an epiphyseal ossification measuring, in section, 0.46 x 0.26 mm.

There are also distinct differences in the shape of the two bones, both of the ossified part and of the cartilaginous part.

These experiments, particularly the second, indicate that a bone which has been relieved of the stress and strain due to the force exerted by the weight of the body and by the action of the muscles, will increase in *length* at practically the same rate as a bone subjected to the action of these forces; that epiphyseal ossification centers will increase in size, but that in the *thickness* of the compacta, such a bone will lag far behind another subject to such forces. It is planned to continue the experiments to an analysis of bone growth in older puppies, and over longer periods of time.

48. Experimental studies on the origin of intraembryonic endothelium and of blood cells. FRANKLIN PEARCE REAGAN, Princeton University.

(a) Cytological and experimental studies on the origin of intraembryonic endothelium—a study of mechanically produced meroplasts. Franklin P. Reagan.

(b) The origin of endothelium and of erythrocytes in hybrid teleosts. F. P. Reagan and James M. Thorington.

(c) The origin of erythrocytes in chemically treated, and in cardiectomized teleost embryos, and in embryos developed at low temperatures. F. P. Reagan.

(a, b, and c). A series of experimental observations lending support to the following propositions:

1. That the embryonic body is capable of furnishing its own endothelium, which develops in loco, in and from the mesenchyme.*

2. That the embryonic body is capable of developing blood-cells which also develop locally.*

3. That pre-endothelial mesoderm (mesenchyme) may be either of direct entodermal origin or from mesenchyme proliferated from visceral or parietal mesoderm, or from coelomic mesothelium.*

4. That endothelium may be obtained in meroplasts in which its origin could not have been from coelomic mesothelium as such.

5. That mesenchyme cells in any region where they are found in bodies of teleost embryos which have developed without circulation may produce erythrocytes whether the circulation has been prevented by certain methods of chemical treatment, by hybridization, by refrigeration, by removal of the heart, or by mechanical or chemical destroyal of the heart anlage prior to heart pulsation; that the anteriorly located erythrocytes of such embryos may or may not be surrounded by endothelium; that the anterior mesenchyme may be (and perhaps generally is) haematopoetic.†

6. That endothelium, as seen in the tail of the living teleost embryo, is formed partly by the active migration of single mesenchyme cells; that such endothelium once formed may grow by its own proliferation.* (This observation has been made by a number of previous observers.)

7. That erythrocytes may develop locally from the mesenchyme in any part of the yolk-sac of teleost embryos lacking circulation and that their origin on the yolk-sac is not restricted to the posterior and ventral yolk-surface.†

8. That the hearts of teleost embryos which have always been devoid of circulation may contain erythrocytes.†*

9. That cardiac endothelium may transform into erythrocytes.†*

10. That myocardial anlagen may transform into erythrocytes.†*

11. That mesothelium may transform into erythrocytes.†*

(Statements followed by an asterisk are at variance with the Angioblast theory of His. Those followed by a cross are opposed to the principal results of Stockard on which he has based his recent support of the so-called Polyphyletic Theory. More complete but preliminary accounts of these observations can be found in the Anatomical Record, vol. 9, no. 4, and in the Anatomical Record, December 1915).

Blood cells and endothelium can be traced back to a very widely distributed mesenchyme, the cells of which are so much alike that it is at present beyond human power to detect differences among them or to determine further their individual lineages. To claim that a cell of this apparently indifferent cell-complex is destined to this or that fate is to argue from authority which one does not possess. To wait until after a cell has differentiated and then claim that the realized outcome was its predetermined fate is to beg the question. Concerning the existence of preformed but unobservable difficulties in such apparently indifferent stages, endless and futile discussions might be precipitated.

The phenomenon itself that different sorts of cells emerge from this apparently indifferent complex need neither be elaborated into a Polyphyletic theory nor into any other theory; it is an undeniable fact that may be verified with the greatest of ease. Certainly no recent observer need claim credit for the discovery of the phenomenon of differentiation. A claim that the divergence of cell-types from an apparently indifferent cell group supports one theory or another is of interest only as evi-

dence of the extent to which its sponsor has missed the fundamental problem involved. The monophyletic view allows and even depends in part on the divergence of unlike cells from apparently like cells which have a wide distribution. If now this is consistent with the polyphyletic view where is the conflict on this point, and why all this phyleticism? The monophyletic view does not preclude the possibility of actual differences at a time before we can observe them; it merely postulates in case of vascular tissues a stage in which mesenchyme cells are truly indifferent, and in which an undifferentiated mesenchyme cell may give rise to diverse sorts of progeny.

Some of us believe, however, that there is, à priori, more to favor the monophyletic origin of a 'diffuse anlage' than there is reason to believe its origin to be polyphyletic. Conversely it may be stated that those who believe in the 'specificity' of vascular tissues (in the narrower sense of the word 'specificity') generally, though not always, realize that their doctrines can stand only when supported by a demonstration of the correctness of the following three postulates—in fact such believers do their utmost to defend these postulates. First, that the particular vascular derivative shall have a restricted locus of origin—a limited anlage. Second, no other tissue shall ever be found producing the tissue of which the 'anlage' is the 'specific' source. Third, the derived type shall never be found producing other types of tissue. *It is in testing the value of these three postulates that we can analyze to a certain extent the developmental processes which operate during the entire 'indifferent' stage. In any event we can produce nothing more than purely à priori evidence for one view or the other.*

The differentiation of divergent types of tissue from apparently indifferent tissue-complexes has been known since cells were discovered and was reasoned about for centuries previous. A 'discovery' that actual but undemonstrable differences exist preformed is at present of little value in that it can neither be proved nor disproved, so far as mesenchymal transformations are concerned.

49. The development of the biliary system in animals lacking a gall-bladder in post-embryonic life. (Lantern slides.) Richard E. Scammon, Institute of Anatomy, University of Minnesota.

The gall-bladder is well known to be consistently absent in a number of species of vertebrates. In others, as in man, congenital absence of the gall-bladder is a more or less rare anomaly. The history of the biliary system has been investigated in three species in which the gall bladder is lacking in post-embryonic life. These are the rat, the pigeon and Petromyzon. In Petromyzon a complete biliary apparatus is formed. According to Nestler and to Bujor this later undergoes regression both of the epithelial walls and the surrounding layer of supporting tissue. In the pigeon a cystic anlage is formed and completely differentiated but increases little in size with the growth of the liver. The gall bladder is carried out on the distal end of the posterior hepatic duct as in other birds. Its regression occurs late in embryonic life and

may take place in several ways. In some cases there is apparently a partial inclusion of the gall bladder in the posterior hepatic duct. In others the bladder may remain, at least temporarily, as a small sac attached to the posterior hepatic duct and lying within its muscular wall. More commonly the bladder becomes detached from the cystic duct, remains for a period as an isolated cyst and finally disintegrates entirely.

The rat has not been completely investigated. In later stages (above 5 mm. in length) there is no trace of a gall bladder. In these stages the hepatic ducts are of large caliber. Helly found no distinct cystic anlage in younger embryos.

50. The embryology and anatomy of the nasofrontal region in man. (Lantern slides.) J. Parsons Schaeffer. The Daniel Baugh Institute of Anatomy and Biology of the Jefferson Medical College.

Owing to contradictory or but general statements concerning the anatomy of the ductus nasofrontalis and the ostium frontale, the writer deemed it important to make a more detailed study of the embryology and gross anatomy of the nasofrontal region.

The nasofrontal region is embryologically an outgrowth from the ventral and cephalic end of the middle nasal meatus and is operculated by the middle nasal concha. The mucosa of this portion of the middle nasal meatus is, therefore, the proton of the frontal recess (early in evidence) and derivatives therefrom. The frontal recess in turn is the anlage of the frontal sinus and some of the ventral ethmoidal cells.

For sometime the lateral wall of the frontal recess is even and unbroken and gives no evidence of the later configuration and complexity. In a four-month embryo the lateral nasal plate of cartilage is thickened at certain points along the lateral wall of the frontal recess. These thickenings are the anlagen of accessory frontal folds or conchae of the middle nasal meatus. In the late fetus one finds a variable number of frontal conchae with a corresponding number of furrows or pits. The number of frontal folds differentiated varies from a complete absence to three or four. The reduced number is doubtless due to lack of differentiation rather than to an earlier fusion of neighboring parts. The frontal pits or furrows vary accordingly. The uncinate process and the folds composing the ethmoidal bulla should likewise be considered as accessory conchae of the middle nasal meatus (analogues and homologues of the frontal conchae) and the ethmoidal infundibulum and the suprabullar furrow as accessory meatuses or furrows (analogues and homologues of the frontal furrows).

The accessory furrows are forerunners of paranasal sinuses. The frontal furrows or pits early evaginate and form ventral ethmoidal cells. It is a well known fact that the frontal sinus develops variously by a direct extension of the frontal recess or from one or more of the ventral ethmoidal cells which have their point of origin in frontal furrows. In many instances the frontal sinus is, embryologically speaking, a ventral ethmoidal cell which has grown sufficiently far into the frontal

region to be topographically a frontal sinus. In a term fetus one is scarcely justified to hazard an opinion as to the specific point in the frontal recess from which the frontal sinus will ultimately develop.

The uncinate process and the folds composing the ethmoidal bulla are often in direct continuity with one or more of the frontal folds or conchae. The relations of these structures vary. Likewise, the ethmoidal infundibulum and one of the frontal furrows or pits are usually in the same axis. It must here be emphasized, however, that it is rare and very unusual for the ethmoidal infundibulum to be directly continuous with a frontal furrow. The latter anatomic fact is significant when one recalls the careless statement repeatedly made that "the ethmoidal infundibulum is continued upwards as the nasofrontal duct into the frontal sinus."

When the frontal sinus develops from a frontal furrow not in the same axis as the ethmoidal infundibulum the relation of the nasofrontal duct to the ethomidal infundibulum is less intimate than in those cases in which the frontal sinus develops from a frontal furrow which is in the same axis as the ethmoidal infundibulum. Even if the latter condition does obtain, the relation is only intimate and not direct. The same argument holds when the frontal sinus develops by a direct extension of the frontal recess.

If the frontal sinus represents a direct extension of the frontal recess, there is in most instances no nasofrontal duct. The frontal sinus in these cases extends well into the ventral and cephalic part of the middle nasal meatus, and a very large proximal ostium frontale represents the point in the frontal recess from which the sinus developed. The ostium frontale in these cases is usually in the same axis as the infundibulum ethmoidale. In the vast majority of cases the infundibulum ethmoidale ends blindly lateral to the frontal recess in a dilated cephalic extremity (infundibular air cell). The latter may encroach bullous-like on the frontal sinus.

When the frontal sinus develops from one or other of the frontal furrows or pits, a varied anatomy of the nasofrontal connections may be expected. In some cases there is a narrow serpentine-like channel (a true nasofrontal duct) of varied length and dimensions communicating between the frontal sinus and the frontal recess. In such cases there are really two frontal ostia, one at the distal end of the nasofrontal duct and the other at the proximal end of the duct, i.e., in the frontal recess.

One or more ventral ethmoidal cells may encroach upon the nasofrontal duct and cause it to deviate from its primary axis. These ethmoidal cells often encroach on the frontal sinus. There are also many frontal sinuses which obviously develop from frontal furrows in which no true nasofrontal duct is present. The frontal sinus in these cases extends in a roomy manner towards the frontal recess of the middle meatus. The proximal ostium frontale in the frontal recess indicates the position of the embryologic frontal furrow or pit. Varied relations of the proximal ostium exist with the infundibulum ethmoidale,—rarely a direct relation, however.

When the frontal sinus appears in duplicate or triplicate obviously two or more ventral ethmoidal cells (from frontal furrows) or the frontal recess and one or more ventral ethmoidal cells developed sufficiently far into the frontal region to be topographically frontal sinuses. With this condition we may again expect varied nasofrontal connections. Each frontal sinus may have a nasofrontal duct. Some or all of the sinuses may present a proximal ostium frontale only in direct relation with the frontal recess.

Rarely the nasofrontal duct is in direct continuity with the ventral and cephalic extremity of the ethmoidal infundibulum. There are two possible explanations for this anatomic condition. Either the ethmoidal infundibulum and the frontal furrow from which the frontal sinus developed were early in direct continuity or the bridge of tissue intervening between the two channels was resorbed at a subsequent time. The latter explanation seems the more probable. Indeed, in many of these cases a superficial bridge of tissue persists, connecting the uncinate process and the ethmoidal bulla, beneath and lateral to which one occasionally finds the nasofrontal duct and the ethmoidal infundibulum in direct continuity. This tends to support the belief that there is a subsequent resorption of the intervening mucous membranes rather than a continuity of channels at a very early time.

Some of the ventral ethmoidal cells developing from frontal furrows or pits remain topographically ethmoid in position. Often, however they encroach on the frontal sinus. Then again it is difficult to classify some; that is, whether they should be called frontal sinuses or ventral ethmoid cells.

This study leads us to conclude that the ethmoidal infundibulum is rarely in direct continuity with the nasofrontal duct or in the absence of the latter, with the proximal frontal ostium. In all cases the frontal sinus communicates with the frontal recess, the communication being established either by a true nasofrontal duct or merely by an ostium placed directly in the caudal portion of the frontal sinus. Furthermore the ethmoidal infundibulum usually develops ventrally and cephalically, lateral to the frontal recess and dilates into a ventral ethmoidal cell (infundibular cell). The nasafrontal duct and the ethmoid infundibulum may or may not be in the same axis, depending from which frontal furrow the frontal sinus developed. It is, therefore, obvious that the relation between the ethmoidal infundibulum and the nasal portion of the frontal sinus is very intimate but not direct. In many instances contiguity and not continuity is the relation. However, from a practical standpoint, the relations are so intimate in at least 50 per cent of the cases that any drainage from the frontal sinus, naturally finds its way into the ethmoidal infundibulum, while in the remaining cases the relations are less intimate and drainage from the frontal sinus finds its way more directly into the middle nasal meatus, medial to the uncinate process. The only exception to this statement is when the ethmoidal infundibulum is directly continuous with the

nasofrontal duct or in the absence of the latter directly with the frontal sinus. It must again be stated that the exception is rare.

This paper is illustrated by lantern slides of reconstructions and of actual dissections. The detailed paper, with figures, is ready for publication and will appear elsewhere.

51. A suggestion as to the process of ovulation and ovarian cyst formation. S. S. SCHOCHET. Department of Anatomy and Histology, Dartmouth Medical School. (Introduced by Dr. F. P. Lord.)

The study here reported has been carried out in a large part in the Anatomical Laboratories, Tulane University, at the suggestion of Dr. Irving Hardesty.

It is generally conceded that pressure atrophy of the ovarian stroma is the chief means by which the extrusion of the ovum becomes possible, as a result of the compression of the blood capillaries between it and the surface of the ovary. (John G. Clark, Johns Hopkins Bulletin 1899). Attention has been directed to the determination of the rôle played by the liquor folliculi.

A series of experiments indicates that the liquor folliculi possesses a digestive enzyme that can be demonstrated by dialysis and other tests. Controls and comparative tests were made with other fluids of the body and indifferent fluids. The results obtained may be tabulated as follows:

1. *Abderhalden's dialyzation reaction*

	Ovarian Tissse	*Muscle*	*Ligament (White Fibrous)*	*Fibrin*
Liquor Folliculi	+++	+++	++	+++
Cystic Fluid	+	+	+	+
Amniotic Fluid	−	−	−	−
Normal Saline	−	−	−	−

2. *Grutzner's fibrin test*

Liquor Folliculi	+++
Amniotic Fluid	−−−

It was noted that there was an increase of stroma (proliferation) instead of an atrophy of the theca of the Graafian follicle. This is not a new fact, but a fact in many instances not sufficiently emphasized.

I believe that I am justified in offering as a tentative interpretation the suggestion that the rupture of the Graafian follicle is due in part to the digestion of the theca by the liquor folliculi. At present I am not in a position to state whether it be (1) a specific ensyme: (2) a concentration of proteolytic substances due to the endosmosis into the antrum of the follicle from the blood current: c. a proteolytic substance as a result of the liquefaction of the follicular cells. If it be a specific enzyme it is suggestive of a typical antibody production.

The paper is illustrated by diagrams and a review of the theories of ovulation.

52. The fusion of the bilateral anlagen of the heart and the formation of the bulbo-ventricular loop in embryos of the cat. H. VON W. SCHULTE. Anatomical Laboratory of Columbia University.

Differences in the details of the fusion between the myoepicardial mantels in mammals have been shown to depend upon the primary position of the mantels in the parietal cavities (Stahl and Carius). They have termed the strip of viscera mesoderm intervening between the mantel and the coelomic angle, the retrocardiac plate, that between the mantel and the lateral limit of the parietal cavity, the precardiac plate. From the former the dorsal mesocardium is formed, from the latter the ventral. The type of fusion is determined by the relative breadths of the pre- and retro-cardiac plates, in particular the proportion existing between the latter and the transverse diameter of the foregut. If the foregut is wise and its retrocardiac plate relatively narrow, the bilateral anlages will be separated by a wise interval when the foregut is closed and will only secondarily come into opposition; the formation of the ventral mesocardium will antecede that of the dorsal (Cuniculus). If the converse proportions obtain—foregut narrow, retrocardiac plate broad, the dorsal mesocardium will be formed before the ventral (Cavia).

The cat conforms in general to the type of the rabbit, although the bilateral mantels are not as widely separated after closure of the forgut as in the shematic figure of Stahl and Carius (1889. Fig. 15). Further the retrocardiac plate is not of uniform breadth in its whole extent but narrows cephalad, so that here the anlages are nearer together and their fusion is accelerated as compared to more caudal portions. The ventral mesocardium is ephermeral and after its disappearance, the myoepicardial mantels are joined by a triangular middle field or plate of mesoderm derived from the precardiac plates, which broadens caudad as the cardiac tubes diverge. The approach of the mantels is accompanied by a contraction of the middle plate, and their ultimate fusion is accomplished by its agency. In these stages it is transformed to an ectal convexity in the line of union, while entally it is defined by longitudinal ridges from the mantels of the two sides. Ultimately the ridges are reduced and the site of the middle field is marked only by a moderate thickening of the myocardium, which marks the primitive axial line of the heart during the formation of the loop. Between the middle plate and the foregut from the deep surface of the former there is active production of mesenchyme, in which endothelial vesicles are formed and subsequently play a rôle in the fusion of the endothelial tubes of the heart.

That the heart tubes become bent prior to fusion was observed by His in a rabbit embryo, and has since been frequently represented (e.g., in the chick Duval, 1889, fig. 88; in the cat, Martin, 1910, fig. 72). The angulation in question is incident at the caudal end of the heart tube and marks its junction with the omphalomesentric veins; it is bilateral and symmetrical. There is in embryos of the cat (8–14 somites) a second bend on each side at the juncture of the bulbus with the

ventricle. Primitively these bulbo-ventricular furrows are symmetrical, and with the abrupt change of diameter from the narrow bulbus to the broad ventricle, give this region of the heart much the appearance of a neck rising between two shoulders (12 somites). The bend of the heart is effected by the deepening of the left and the gradual obliteration of the right bulbo-ventricular furrow. It is in its innition as though the left shoulder were raised, the right dropped (14 somites). The left furrow and shoulder are no longer distinguishable in external view at 16 somites, though entally the fundus of the left bulbo-ventricle furrow is still perceptible as a low ridge; the right furrow deepens and persists as the definitive bulbo-ventricular fissure.

The endothelial tube in these stages conforms in general shape to the myoepicardial mantel. The junction of the bulbus with the ventricle is greatly constricted and sharply bent around the fundus of the bulbo-ventricular fissure on each side. In consequence, the endothelial tubes are early brought into apposition in their bulbar segments. In the ventricular region they diverge and again approach one another at the caudal bend at the junction of the heart tube and the omphalo-mesentric vein. Fusion is accomplished by the incorporation of the mesenchyme and endothelial vesicles of the middle field into the endothelial tubes of the uniting cardiac anlages. It is first effected caudad in the region of the sinus venosus; almost at the same time, however, it begins also at the bulbo-ventricular isthmus (14 somites). The ventricles still show remnants of the septum in embryos of 19–20 somites. The definitive bulbus is derived chiefly from the right endothelial anlage, the auricle chiefly from the left, for in both of these situations one tube enlarges, the other diminishes in size, eventually becoming interrupted in its continuity, and is only partially utilized in the formation of the single cardiac tube.

See 65, KATHERINE J. SCOTT, page 263.

53. On the osteology of the fishes of Bermuda. R. W. SHUFELDT, *Washington, D. C.**

Several years ago, while living in the city of New York, Dr. Charles H. Townsend, Director of the New York Aquarium, invited my attention to the fact that many of the living fishes, constantly being transported from the Islands of Bermuda for exhibition purposes at the Aquarium, died, either during transportation in the tanks in which they were kept, or succumbed to the effects of the trip shortly after their arrival. It was pointed out to me that this material was in excess of what was required for the series of alcoholic specimens, or for the use of the schools and other laboratories in the State.

The suggestion was made by me that a series of skeletons of these interesting forms be prepared, and subsequently figured and described, if possible. This idea appealed to Doctor Townsend; he offered me the use of the laboratory in the Aquarium building, and the services of those of the staff who could assist me in the work. During the two years that followed, I devoted from two to three days a week to the skeletonizing of the various specimens of fishes that came into my

hands from the aforesaid sources; so that, at the end of that time, when I returned to Washington to continue my researches in biology and other branches, I found I had prepared for study and description over sixty skeletons of the representative species of the ichthyfauna of the Bermuda Islands. These included such interesting forms as all the varieties of the Parrot fishes (*Scarus*, *Pseudoscarus*, and their allies), the Moras (*Murœna*), the Groupers, Red Hind, Trunkfishes, Porcupine fish, various species of Angel fishes, Pompano, Hog-fish, Turbot, and others too numerous to mention.

My first labor upon these was to prepare a series of photographic negatives of them. This work has now been carried to a point where I find in my collection a nearly complete array of these, and from them I have made many valuable photographs to illustrate my forthcoming contributions in this field of research.

The very distinguished ichthyologist, the late Dr. Theodore Gill, examined, shortly before his death, not only my set of photographs illustrating the skulls, skeletons, and other parts of these Bermuda fishes, but he was so good as to go over some of the material itself, remarking at the time that my studies of these forms should certainly be completed and published. Some of this is quite ready for publication at this writing, and much else of it can easily be so prepared. There is very little being done at the present time in the skeletal structure of fishes; and as a matter of fact there is but scant literature on this important department of biology.

Very well do I remember the interest Doctor Gill evinced as he examined some of my preparations; and upon several occasions he remarked, as he held one or another of them in his hand: "Here is a point that should be carefully worked, as we have little or nothing upon the osteology of this species."

It would be quite out of the question for me to fully abstract my work in this direction as far as it has been carried up to date, for that would soon overrun the legitimate space limits. However, I may say that, in view of the fact that so little—so very little comparatively—is now being done in anatomical structure of fishes in this country, contributions on the subject should be quite welcome, not to say useful. It is my hope to complete my work on this material in due course; when it is sufficiently advanced to commence publication, and not subjected to subsequent interruptions, I further hope to have some of it appear in the Anatomical Record, or, perchance, in some of the various other publications of The Wistar Institute.

54. A disguised type of smooth muscle cell. R. A. Spaeth. Osborn Zoölogical Laboratory, Yale University. (Introduced by R. G. Harrison).*

The melanophores of the lower vertebrates—fish, amphibia and reptiles—are described by most authors as modified connective tissue cells. The evidence for such a conception rests chiefly upon a morphological basis. Leydig showed that no sharp morphological distinc-

tion exists between unpigmented connected tissue cells, inactive, pigmented connective tissue cells and chromatophores (melanophores) containing actively migrating pigment granules.

Morpholgical characteristics alone are not, however, sufficient finally to classify any type of cell. Little evidence is to be adduced from the embryological history of the melanophore concerning its ultimate nature, since both connective tissue cells and melanophores develop from wandering mesenchyme cells. However, a consideration of the physiological responses of the melanophore shows that it bears a far closer resemblance to certain types of smooth muscle cells, e.g., those of the sphincter pupillae, the digestive tract, and the radial elements of the cephalopod chromatophores, than to any type of connective tissue cell. Thus, for example, chemical, electrical and thermal stimuli which produce contractions in these three types of smooth muscle also bring about contractions in the melanophore. Appropriate treatment with $PaCl_2$ initiates a slow pulsation in the melanophore. A study of the rate of rythmic contraction shows it to be of the same order as the spontaneous contractions of excised portions of the digestive tract.

The work of Chun has shown conclusively that the chromatophores of cephalopods develop from single smooth muscle cells by a complicated metamorphosis. Thus the establishing of the vertebrate melanophore as a modified smooth muscle cell—a view previously suggested by Steinach, Franz and Hoffman and formerly questioned by me, is of particular significance, since it reduces the color-changing mechanisms of both vertebrates and invertebrates to a common basis, i.e., a specialized type of smooth muscle cell.

In the melanophore, the motor function of the smooth muscle cell is lost and there is developed a modified motility in the migration of pigment granules, which may serve as a means of protecting the animal. An analogous case in that of the electric organ in fish where a striated muscle cell loses its motor function completely, and the action current, normally of relative insignificance, becomes a physiological end in itself and a formidable means of protection.

55. *Growth of the body and of the various organs of young albino rats upon refeeding after inanition for various periods.* C. A. Stewart, Institute of Anatomy, University of Minnesota. (Introduced by C. M. Jackson.)*

Eight litters, including 45 rats, were used, of which 9 were controls. Of the experimented rats, 3 were repeatedly starved and refed for short intervals. The others were refed for various periods of maintenance (from age of 3 weeks to age of 4, 6, 10, and 12 weeks).

The average daily loss in weight did not increase in the rats repeatedly starved, and no effect upon the ultimate body weight was noted.

The growth in body weight of the rats refed after maintenance for various periods averaged considerably higher for some time than the normal for (younger) controls of the same body weight. Thus the stunted rats on refeeding were able to overtake the full-fed controls before the end of the normal growth period.

As to body proportions, the relative weights of the head, trunk and extremities remain practically normal during the various periods of refeeding after maintenance.

Of the systems, the musculature and 'remainder' continue practically normal (for corresponding body weight) during the various periods of refeeding. The integument rapidly increases and the skeleton decreases in relative weight, so that both reach their normal proportions within the first two weeks of refeeding after maintenance from three to ten weeks of age.

The viscera which lose weight during maintenance,—thymus, spleen, thyroid, lungs and ovaries,—likewise apparently regain their normal relative weight within two weeks. The thymus (and possibly the lungs and spleen) are even above normal at four weeks of refeeding, but all are found nearly normal in rats refed to the adult stage.

The viscera whose weight remains nearly constant during maintenance,—brain, heart, kidneys, liver and epididymi,—in general present approximately normal proportions during the process of refeeding; although the heart appears slightly above normal, and the epididymi somewhat below.

The viscera whose weight increases during maintenance,—eyeballs, spinal cord, alimentary canal, hypophysis, testes and suprarenals,—have in general decreased in relative weight so as to approach the normal within the first four weeks of refeeding.

56. Experimental modification of the chromatin within the germ cells of one generation and the resulting hereditary transmission of degeneracy and deformities. (Lantern.) CHARLES R. STOCKARD, Cornell Medical School, New York City.

The results of an experiment now in progress for more than five years permits to some extent an analysis of the influence on the offspring of alcoholizing either one or both parents and the manner of hereditary transmission of the induced effects to subsequent generations.

The experiments have demonstrated on two different stocks of normal guinea-pigs that the parental germ cells may be so modified by chemical treatments that they are rendered incapable of giving rise to a perfectly normal offspring. This incapacity is probably due to modifications of the chromatin, or carriers of the hereditary qualities, within the germ cells since the great-grandchildren, the F_3 generation, from the treated animals are usually more decidedly affected and injured than the immediate offspring (F_1) of the alcoholized animals.

This then becomes a study of the behavior of diseased or pathological chromatin in heredity. Chromatin rendered pathological more than four years ago is still living and has now been passed on to the F_3 generation from the alcoholized great-grandparents. The F_3 animals are almost without exception incapable of reproduction and are in many ways subnormal and degenerate.

Studies of abnormal heredity may possibly furnish a means of analyzing the normal methods of action by which the minute carriers

of hereditary qualities contained within the fertilized egg are capable of causing the complex developmental and structural changes to reoccur from generation to generation in so wonderfully consistent a manner. Just as the knowledge furnished by studies of experimentally modified embryonic development has supplied valuable data towards a clearer understanding of the normal processes and changes which occur in the developing embryo.

The treatment of adult guinea-pigs by an inhalation method with daily doses of alcohol through several years produced little if any noticeable effect upon the organs and tissues of the animals' body. The direct action of alcohol fumes tends to injure the mucosa of the respiratory tract and to render the cornea of the eye dull or opaque. These changes, however, do not inconvenience the animals in any perceptible way, and they remain strong and hardy and live as long and actively as the untreated guinea-pigs. In spite of their healthy appearance the injurious influence of the alcohol inhalation is very decidedly shown by the quality of offspring to which the treated guinea-pigs give rise and the descendants of these offspring are even worse than the F_1 generation when compared with the different generations of control animals produced under identical cage and food conditions.

The males seem to be more injured by the treatment than the females taking as an index of injury the quality of their offspring and descendants. Stating it differently the spermatocytes or spermatozoa are more sensitive to the changed chemical condition of the tissues than are the female germ cells.

There is a larger proportion of degenerate, paralytic and grossly deformed individuals descended from the alcoholized males than from the alcoholized females.

The records of 667 offspring produced by 566 matings of animals of various types have been tabulated to show the kinds of litters of young produced and their ability to survive. One hundred and sixty-four matings of alcholized animals, in which either the father, mother, or both were alcoholic gave 64, or almost 40 per cent negative results, or early abortions, while only 25 per cent of the control matings failed to give full term litters. Of the 100 full term litters from alcoholic parents 18 per cent contained still-born young, and only 50 per cent of all the matings resulted in living litters, and 46 per cent of the individuals in the litters of living young died very soon after birth. In contrast to this record 72 per cent of the 86 control matings gave living litters and 84 per cent of the young in these litters survived as normal healthy animals.

The mating records of the descendants of the alcoholized guinea-pigs although they themselves were not treated with alcohol compares in some respects even more unfavorably with the control records than did the above records of the directly alcoholized animals.

Of 194 matings of F_1 animals in various combinations 55 have resulted in negative results, or early abortions, 18 still-born litters of 41 young occurred, and 17 per cent of these still-born young were deformed.

One hundred and twenty-one living litters contained 199 young, but 94 of these died within a few days and almost 15 per cent of them were deformed, while 105 survived and 7 of these showed eye deformities. Among 115 full-term control young of the same stock not one has been deformed.

The records of the matings of F_2 animals are still worse, higher mortality and more pronounced deformities. While the few F_3 individuals which have survived are generally weak and in many instances appear to be quite sterile even though paired with vigorous prolific normal mates.

The structural defects seem to be confined chiefly to the central nervous system and special sense organs. Many of the young animals show gross tremors, paralysis agitans, or the hind legs, fore legs or both legs of one side may be paralyzed. Eye defects are very common such as opaque cornea; opaque lens, various degrees of monophthalmica asymmetrica and finally several cases of complete anophthalmia have occurred the entire eye ball, optic nerve and optic chiasma being absent.

The quality of the individuals from the same parentage varies inversely with the size of the litters in which they are produced. Animals born one in a litter are rather strong even though derived from very bad alcoholic lines. This difference between the members of small and large litters is also shown by the normal animals but the differences between members of large and small litters is ever so much greater in the alcoholic lines.

Inbreeding tends to emphasize the alcoholic effects. This is probably due to the related animals responding to the treatment in closely similar ways on account of the similarity of their constitutions. Inbreeding as such, may be harmful. But inbreeding added to the alcohol effects produces a much more serious condition in the offspring than either inbreeding or alcoholism alone could do.

The data from alcoholized male lines indicates that the *female offspring from alcoholic males are less viable and more frequently deformed than the male offspring. And heterogeneous matings of such male and female offspring further emphasizes the same inferiority on the part of the female offspring from treated males.* This is a very significant fact.

The fact that the offspring of one sex differs in quality from those of the opposite sex and that the female offspring of an alcoholic male are inferior to his male offspring suggests at once a difference between the germ cells concerned in the production of the male and female young. Miss Stevens showed that the spermatocytes of the male guinea-pig contained a heteromorphic pair of chromosomes and half of the spermatozoa would be expected to receive one member, the x chromosome, of the heteromorphic pair and one-half of the spermatozoa the other member, the y chromosomes, of the heteromorphic pair. We now have two possibilities in explanation of the above facts. In the first place, it may be assumed that the alcohol acts similarly on all of the chromatin to injure it. Thus a mass action would cause the spermatozoa carrying

the larger member of the heteromorphic pair to deliver more injured chromatin and the other spermatozoa with a less total amount of injured chromatin would deliver less when they fertilize eggs containing equal amounts of normal chromatin. The fertilized egg giving rise to the female, therefore, contains a greater proportional amount of alcoholic chromatin to normal chromatin than does the egg giving rise to the male, and so the female product is actually more injured than the male.

A second possible explanation of these conditions may be that the x and y chromosomes themselves respond differently to the treatment, the x being the more sensitive of the two. But in either case the two classes of spermatozoa certainly seem to respond differently to the treatment and this shows a physiological difference in behavior to correspond with the well known morphological differences so often shown between the two groups of spermatids of many animal species.

The data from alcoholic female lines indicates that *the male offspring from alcoholic females are inferior in quality to the female offspring. And heterogeneous matings of such male and female offspring further prove the inferiority on the part of the male offspring from treated females.* This is also significant. How can it be put in accord with the above chromosomal explanations for the difference in quality between the female and male young of alcoholized fathers?

If we admit that all of the eggs arising from an alcoholized female guinea-pig are homomorphic and contain groups of chromosomes equal in mass, it follows that her male and female offspring receive the same amount of injured chromatin and should be affected by such chromatin to equal degrees. But this is only part of the case, the injured female chromatin is combined with normal chromatin from the normal father when the eggs are fertilized and here the difference arises. The female offspring receives from the normal father a larger amount of normal chromatin than do the male offspring. So that the female arises from an egg in which equal amounts of good and injured chromatin are present while the male offspring arises from an egg in which a larger amount of injured chromatin is united with a smaller amount of normal. Therefore, proportionally the male offspring has more injured chromatin in his entire bodily make-up than does the female and is comparatively in a more abnormal condition.

Another explanation of these differences between the male and female offspring of alcoholized females could be based on the possibility of the female being heterozygous for sex. This involves a very complex discussion but one for which there is some ground on the basis of the regulation of the sex ratio in these animals.

Finally then, the experiments show the hereditary transmission through several generations of conditions resulting from an artificially induced change in the germ cells of one generation. And they furnish data of importance bearing upon the pathological behavior of the carriers of heredity as well as the differences in behavior between the two types of germ cells produced by an animal carrying heteromorphic chromosomes.

57. Development of the scala vestibuli and scala tympani and their communications in the human embryo. GEORGE L. STREETER, Carnegie Institution, Embryological Research, Baltimore.

The perilymphatic spaces are formed by the coalescence of mesodermal tissue spaces surrounding the membranous labyrinth and closely resemble in their formation the subarachnoid spaces. They cannot, however, be regarded as subarachnoid spaces that have invaded the region of the internal ear, because their development is in loco and independent of the latter. In the latest stage examined (130 mm. crown-rump length) the communication with the subarachnoid spaces is not yet established.

In their formation the perilymphatic spaces follow a definite morphological plan. They spread from two foci; the larger one begins as a rounded sac lying opposite the foot-plate of the stapes and lateral to the sacculus, from which point it subsequently spreads upward over the utricle and also downward along the apical side of the cochlear duct to form the scala vestibuli; the other focus is near the fenestra rotundum from where it spreads along the basal side of the cochlear duct to form the scala tympani. These foci can be definitely outlined in fetuses 50 mm. long. In 85 mm. fetuses the two scalae extend spirally downward along the cochlear duct to a point three-fourths of its last turn from the tip of the duct and they do not communicate with each other. In 130 mm. fetuses they extend to the tip of the cochlear duct and open into each other forming the helicotrema.

The semicircular canals acquire their perilymphatic spaces relatively late. In the 130 mm. fetus the lateral canal has a space throughout one-half its length. The remainder and that of the other canals are acquired after this.

58. The supra-optic canal, its morphology and anatomical relation to choked disc. FREDERICK TILNEY, Department of Anatomy, Columbia University.

In a recent paper[1] the writer called attention to the presence of a small canal extending out from the third ventricle above the optic nerve and chiasm. This I called the *Supra-Optic Canal.* It was first observed in studying the fore-brain of the domestic cat. In this animal the canal projects laterad from the cephalic extremity of the ventricle across the optic chiasm and for a short distance into the optic nerve on either side. It is lined with ependyma and measures 0.75 mm. in length. It is situated upon the dorsum of the chiasm and in this position extends along the optic nerve. The canal is marked upon the surface by a ridge running along the dorsum of the optic chiasm and optic nerve. This is the *Supra-Optic Ridge.*

I have observed this canal in the following forms: Squalus acanthias, Mustelus laevis, Lepidosteus osseus, Rana pipiens, Menobranchus,

[1] Morphology of the Diencephalic Floor: A contribution to the Study of Craniate Homology. Journal of Comparative Neurology, 1915, vol. 25, no. 3.

Iguana tuberculata, Gallus gallus, Botaurus lentiginosus, Didelphys quica, Bradypus tridactylus, Dipus aegyticus, Dasyprocata agouti, Mus decumanus, Lepus sylvaticus, Sphingurus prehensilis, Mephitis mephitica, Odocoelus hemionus, Odocoelus virginianus, Oryx beatrix, Ovis aries, Castor canadensis, Mirounga (Macrorhinus augustirostris), Nasua narica, Ursus horribilis, Canis latrans, Canis familiaris, Genetta vulgaris, Felis domesticus, Felis pardus, Felis leo, Lemur macaco, Macacus cynomolgus, Nyctipithecus trivirgatus, Babuin cynocephalus, Hylobates hoolock, Simia satyrus, and Homo.

The existence of a canal phyletically so constant as this one, must have some definite ontogenetic explanation. This was sought for in the embryology of several forms and found to be thoroughly consistent in all of them, so that the conditions in the cat may serve as a paradigm for the vertebrate development of this accessory recess of the third ventricle.

At the early stage of eight somites in the cat embryo, the entire cephalic expansion of the neural tube is given over to the formation of the primitive optic vesicles which contain a large prosencephalic ventricle. A little later, these primitive vesicles show a constriction which causes the appearance of two small evaginations now recognizable as the definitive optic vesicles. Each of these evaginations contains a recess accessory to the prosencephalic ventricle.

The definitive optic vesicles then proceed to give rise to the eye-cup which retains its connection with the brain by means of an attenuated stalk. Through this stalk passes a narrow canal, the remnant of the former spacious connection between the fore-brain and the eye vesicle. Thus it is obvious that the embryonic basis of the supra-optic canal is to be found in this small tubular extension from the third ventricle. The fibers which form the optic nerve and optic chiasm grow into and through the optic stalk with the result that these fibers take up a position ventral to the canal, thus causing the supra-optic recess of the ventricle to rest upon the dorsum of the optic nerve and chiasm.

In the majority of forms the proximal portion of the canal alone persists into adult life. Osborne, Herrick and Kingsbury, have shown, however, that the rudimentary condition of the eye in Necturus is accompanied by a similar condition of the optic nerve which retains in the adult the primitive lumen of the optic vesicle and is hollow for a considerable distance peripherad.

The history of this canal is clear, both from the embryological and the phyletic standpoints. It remains to inquire what clinical significance it may assume in cases where there is an accumulation and retention of fluid in the fore-brain ventricles. Obviously, such a canal placed in such relation to the optic chiasm and nerve might bring pressure to bear upon the fibres of these structures and thus interfere with the normal hemal and non-hemal drainage in this part of the nervous system. Should the canal become dilated, there is but one result possible, namely, a compression of the optic fibres lying beneath it.

What happens to this canal in the event of dilatation is shown in a

case of internal hydrocephalus in a child four years of age which presented a bilateral choked disc. There can be no question that the distention of the supra-optic canal caused profound changes as compared with the normal. The actual alterations are easily appreciated, as follows:

First, the obliteration of the supra-optic ridge by a flattening out of the roof of the canal; second, the thinning of the ependymal lining of the canal; and third, the evidence of compression of the optic fibers as they pass beneath the canal.

The appearance of choked disc in brain tumor is variously estimated as occurring in from 80 to 90 per cent of all cases. Papilledema, however, is much more constant than this in internal hydrocephalus. Opinion today is turning toward the belief that it is the complicating internal hydrocephalus, occasioned by the tumor, which produces the edema of the optic nerve. Such a view would explain the absence of choked disc in a certain percentage of brain tumor, for it is possible that some new growths may exist without compromising the ventricular chambers. This would be particularly true of the endotheliomata in which the surface pressure is often so diffuse as to cause no appreciable change in the size or relations of the ventricles. On the other hand, extremely small tumors if rightly placed, as for example, in the neighborhood of the aqueduct of Sylvius may occlude the passage between the third and fourth ventricles, thus causing retention of the fluid in the third and lateral ventricles.

The causation of choked disc from this viewpoint would require the establishment of an internal hydrocephalus. This does not in any way preclude the possibility of the production of papilledema due to increased pressure in the intervaginal sheath. As far as our knowledge permits today, it seems admissible to conclude that choked disc may be the result of the following mechanical disturbances in the anatomical relations.

1. Increased intercranial pressure operating particularly upon the fluid in the sub-arachnoid space and so causing distention of the intervaginal space around the optic nerve (Manz-Schmidt-Rimpler theory); 2, internal hydrocephalus which produces a distention of the supra-optic canal, and in this way puts pressure upon the optic nerve and chiasm; 3, both of these mechanical disturbances may be operative at the same time.

As to the so-called toxic theory of Leber in the causation of choked disc, the facts at present seem to warrant its acceptance. But it should be held with some reservation since we are not yet in a position to state the exact modus operandi of such toxic substances as may cause a swelling of the disc It is possible for example, that such toxins should act directly upon the nerve to cause edema or again upon the ependyma of the ventricles causing a swelling of the ependymal epithelium, thus producing internal hydrocephalus which actually becomes the underlying cause of choked disc. This aspect in the pathogenesis of papilledema must receive still further investigation. On the other hand, with reference to the mechanical elements operative in the causation

of choked disc, it now seems justifiable to supplement our previous conceptions by the rule which the supra-optic canal may play in the causation of papilledema as the direct result of internal hydrocephalus.

59. Observations on the mitochondrial content of the cells of the nuclei of the cranial nerves. M. DeG. Thurlow, Anatomical Laboratory, Johns Hopkins University. (Presented by E. V. Cowdry).

The purpose of this investigation was to determine whether the amount of mitochondria could be used as a basis for classifying nerve cells into motor and sensory groups. The problem was suggested by the striking amount of mitochondria present in the cells of the mesencephalic nucleus of the V nerve, an amount sufficient to distinguish the cells in it from every other cell in the medulla and giving them an appearance similar to spinal ganglion cells.

White mice were used, and the observations were confined to the cells of the nuclei of the cranial nerves because these may more readily be classified into somatic sensory, visceral sensory, visceral motor and somatic motor divisions. The brains were fixed by a special method which permits of the study of both the Nissl substance and the mitochondria differentially stained in the same cell. The individual mitochondria were counted and the number per cubic millimetre of cytoplasm determined, this serving as the basis for the comparison.

The mesencephalic nucleus of the V, the cochlear and vestibular nuclei of the VIII, the nuclei of the VI and VII nerves were chosen for study because these nuclei seem to represent extremes in the amount of mitochondria. In the cells in individual nuclei the quantitative variations in mitochondria are but slight although the variation is great as between the cells in different nuclei. The largest amount of mitochondria was found to be present in the mesencephalic nucleus of the V, the smallest amount in the nucelus of the VII. This would seem to indicate that sensory cells differ from motor cells by the amount of mitochondria within them, but this in reality is not the case because there are large amounts of mitochondria in both sensory and motor cells (e.g., the cochlear nucleus of the VIII and the nucleus of the VI), while in striking contrast to this are other motor and sensory cells (e.g., the nucleus of the VII and the vestibular nucleus of the VIII) containing a greatly reduced amount. Furthermore, the motor cells of the VI nerve contain more than the sensory cells of the vestibular nucleus of the VIII, and the sensory cells of the cochlear nucleus of the VIII contain relatively more mitochondria than the motor cells of the VII nerve, so that we have examples of motor cells containing more than sensory cells, and of sensory cells containing more than motor cells.

It is evident that the mitochondrial content cannot be used as a basis of classification of sensory and motor cells, although the cells of certain nuclei of the cranial nerves can be recognized with certainty by the relative amounts of mitochondria within them. Variations in amount of mitochondria are not without significance in view of the numerous observations on changes in the amount of mitochondria, with activity, in other than nerve cells.

60. The position and relations of the sex gland in early human embryos. (Lantern.) JOHN WARREN, Harvard Medical School.

The object of this communication is to point out the changes in the position of the sex gland and the consequent variation in its relations to the abdominal organs in the earlier stages of development. The sex gland first appears as a mere superficial thickening covering the ventral and mesial surfaces of the Wolffian body, and does not exert any special impression on the neighboring organs apart from that due to the Wolffian body itself. In an embryo of 9.4 mm. this anlage has rather ill defined limits, but extends approximately from the level of the sixth and seventh to a point between the tenth and eleventh thoracic nerves. The Wolffian body at this stage begins opposite the last pair of cervical nerves and ends near the last pair of thoracic nerves.

In an embryo of 10.2 mm. the sex gland has assumed definite proportions, and is raised above the surface of the Woffian body so as to make distinct impressions on the organs in relation to it. The upper end of the Wolffian body lies between the second and third pair of thoracic nerves. The upper pole of the sex gland is opposite the fourth pair of thoracic nerves and immediately below the opening between the pleural and peritoneal cavities, while the lower pole terminates between the first and second pair of lumbar nerves. The cephalic end of the gland is practically in relation to the lung on both sides Below this lung area anteriorly on the right gland comes an hepatic area forming an impression on the posterior surface of the right lobe of the liver and below the liver an intestinal area. Towards the lower end there is a mesial surface in relation to the mesentery. On the left side the gland is in relation anteriorly first to the greater curvature of the stomach, then to the great omentum and below the latter the anterior surface is free. The mesial surface is towards the mesentery.

In an embryo of 16 mm. these relations become more complicated and owing to the unusual size of the gland deeper mpressions are formed on the organs with which it is in contact. The upper end is at the level if the top of the ninth thoracic pair of nerves and ends below at the top of the second pair of lumbar nerves. The upper end of the mesonephric folds in which the Wolffian bodies develop, is prolonged above from the diaphragm to the top of the Wolffian body and lies just lateral to the opening between the pleural and peritoneal cavities. These folds which make deep impressions on the right and left lobes of the liver, form with the Wolffian bodies and sex glands a prominent ridge on the dorsal wall of the abdominal cavity, and this ridge is prolonged by means of the gubernaculum to the ventro-lateral wall of the abdomen. In this way the dorsal wall on either side of the mesentery of the intestine is divided into a lateral region external to the ridge and a mesial region internal, between it and the mesentery. Furthermore these ridges make longitudinal grooves in the various organs on either side of the general vertebral groove. The right sex gland is in relation anteriorly for its whole extent with the liver, being deeply imbedded in that organ. The Müllerian duct also causes a distinct impression on the liver external

to that caused by the gland. The Wolffian body lies dorso-lateral and the adrenal and lower down, the cardinal vein dorso-mesial. While the greater part of the gland lies rather transversely, the lower part makes a half turn so that its long axis lies antero-posteriorly and takes a position between the Wolffian body and the intestine. On the left side the sex gland has the same posterior relations as the right, while anteriorly it presents, in succession from above downward, first a ventro-mesial surface for the stomach and a ventro-lateral surface for the liver, which is later succeeded by a splenic surface, the spleen intervening between the gland behind and the liver and stomach in front. Below and internal to the spleen comes an omental surface and still lower a pancreatic. Below the pancreas the gland makes the half turn already described, and the gland then lies between the Wolffian body externally and the mesentery internally, while anteriorly the omentum covers it nearly to the lower end.

In an embryo of 25 mm. the upper end of the gland lies opposite a point between the eleventh and twelfth thoracic nerves while the lower end is opposite the second pair of lumbar nerves. As the upper pole has descended from the level of the ninth to that of the twelfth pair of thoracic nerves, the relations especially on the left are somewhat modified though the impressions on the various organs are more accentuated owing to the increased size of the gland. Both glands now have renal surfaces behind the relation to the primitive kidneys and lie much more free in the abdominal cavity, being attached to the dorsal wall by their mesenteries only. On the right side there appears a mesial surface in relation to the duodenum and lower a smaller area in contact with the head of the pancreas. The gland then turns mesially and is moulded against the intestine and its mesentery below the duodenum. On the left there is no longer any gastric surface, the gland being first in relation anteriorly to the liver and then to the spleen which separates it from the stomach. Below the spleen comes the pancreatic and omental surfaces, the latter organ receiving a deep impression from the gland. In other respects the relations are the same as in the preceding stage.

Beyond this stage the gland rapidly descends along the dorsal wall of the abdomen and in an embryo of 37 mm. extends from the third lumbar to the fifth lumbar and first sacral nerves. Only the upper ends of both glands lie in contact with the kidneys and rest below on the dorsal wall along the psoas muscle. The right gland is still entirely covered in front by the liver and more mesially by coils of intestine. The upper end of the left gland is just touched by the omentum but otherwise is imbedded in coils of the intestine. In the oldest stage studied, an embryo of 42 mm., the gland extends from the fourth lumbar to the fifth lumbar and first sacral nerves and is entirely below the kidneys. On the right side the gland is covered anteriorly by liver and mesially by intestine, while on the left the intestine practically surrounds it. The mesentery of the colon and part of the colon itself are folded over the top of the left gland and lie partly behind its upper end. Below the liver both glands are in relation mesially with the wall of the

bladder and make impressions especially on that part of the lateral wall of the bladder in which lie the umbilical arteries. Both glands occupy a shallow fossa in the angle between the dorsal and lateral walls of the abdomen. The upper end of the original mesonephric fold can be traced along the outer border of the kidney for a considerable distance and is continuous below with the mesentery of the gland which runs along the outer border of the psoas muscle and then obliquely across it towards the pelvic brim.

61. The establishment of the circulation of cerebro-spinal fluid. Lewis H. Weed, Johns Hopkins University.

Data regarding the establishment of the circulation of cerebro-spinal fluid in the embryo may be obtained by replacing the existent fluid in the ventricles and in the central canal of the spinal cord by foreign substances. This replacement may be accomplished by a simple compensatory device which provides for the simultaneous introduction and withdrawal of fluid. As used in this work and found successful; such a mechanism may be constructed of two reservoirs suspended by cord over a pulley, so that as one is raised the other is lowered to an equal degree. These reservoirs are in turn connected by rubber tubing to two needles, held on brackets at the same level. One of these needles is inserted into the central canal of the spinal cord, the other into the mesencephalic or lateral ventricle. The replacement has been done on numerous living pig embryos of various stages; these embryos were then kept alive for varying periods, up to two hours, by placing them in a 38° incubator.

It was felt that reliable results in any problem involving the possible passage of fluid through a membrane could only be studied by the introduction of a true solution, followed by the subsequent precipitation of the foreign salts in this solution. For this purpose, isotonic solutions of potassium ferrocyanide and iron-ammonium citrate in equal amounts, were used, as these salts were found non-toxic, not attracted to specific cellular elements and in the strength used, non-coagulants of protein. The fixation of this material in a fluid containing dilute hydrochloric acid caused the formation of Prussian blue which was insoluble in the routine histological technique. For comparison, solutions of silver nitrate and suspensions of carbon granules (india ink) were employed.

With this method of investigation—the replacement of the existent medullary fluid by a true foreign solution without increase in pressure—evidence of a trustworthy character in regard to the course and distribution of the cerebro-spinal fluid may be obtained. The further spread of this replaced fluid must be caused by a normal intraventricular production of the normal fluid.

If in a living pig embryo of 8 mm. an injection (specimens of this size are somewhat too small for replacement) of the ferrocyanide solution be made into the central spinal canal, under mild pressure from a syringe, the distribution of the fluid (as evidenced by the precipitated granules of Prussian blue), remains strictly intraventricular even

though the embryo is kept alive for some time after the injection. In embryos of 12 to 13 mm., replacements of the fluid may be made. At this stage, the results differ from those of the smaller embryos only in the collection of dense granules in an oval region in the superior central portion of the roof of the fourth ventricle. Histologically this aggregation of granules occurs against a rounded differentiated area in the ependymal lining of the ventricle.

The first evidence of an extra-ventricular spread of this replaced fluid occurs in pig embryos of over 14 mm. This extension of the solution from the ventricle occurs from the same differentiated area in the rhombic roof, against which the granules collected in the earlier stage. This spread is approximately coincident with the development of tufts in the choroid plexuses of the fourth ventricle. The area of ependymal differentiation, which has been termed the area membranacea superior, comes to lie in the superior half of this roof when the division caused by the laterally developing plexuses occurs.

In 18 mm. pig embryos subjected to similar replacements, the extra-ventricular spread is by no means extensive; two areas, however, of escape for the ventricular fluid are made out locally in the two divisions of the rhombencephalic roof. The superior of these points of fluid-passage is the same concerned in the primary outflow of the fluid while the inferior is a somewhat similar area of ependymal differentiation in the caudal half. The first microscopic evidence of this inferior area is found in pig embryos of 15 mm.

After this stage is passed, the further extra-ventricular extension of the fluid occurs rapidly. The peribulbar spaces are first filled with the fluid and from this region, a spread downward in the perispinal spaces occurs. Simultaneously with this caudal enlargement of the fluid spaces, the replaced fluid may be traced along the ventral surface of the mesencephalon. In pig embryos of 23 mm., these replacements show a total filling of the ventricular system with the blue and an almost complete surrounding of the cerebro-spinal axis with the granules. The superior portion of the mesencephelon and the cerebral hemispheres are the last parts of the nervous system to show evidence of a pericerebral investment. This final establishment of the adult cerebro-spinal relationship occurs in pig embryos of about 26 mm.

Similar stages in the filling of the spaces about the nervous system may be obtained by simple injections with this true solution into the central canal of the spinal cord under very mild syringe-pressure. The employment of the ordinary moderate pressure of injection results in similar spreads of the fluid but always in earlier stages than are obtained by the replacement method. Strong syringe-pressure, below those causing obvious ruptures, result in the further decrease in the stage necessary for a given type of spread.

For comparison with these results, injections and replacements of india ink were made. No extraventricular spread of this granular suspension was obtained in any replacement experiment. With the use of syringe-pressures markedly above the normal, the ink could be

forced outward from the roof of the fourth ventricle. The spread, however, was always much less extensive than after replacement with the ferrocyanide in an embryo of the same size.

The use of silver nitrate gave results valuable only for the sake of comparison. The power to coagulate protein apparently caused many artefacts and led to very limited spreads.

The two areas of ependymal differentiation in the two halves of the rhombic roof are both intact membranes, apparently devised for the passage outward of the ventricular fluid. Both differentiate at a slightly earlier stage than that at which they function actively. In the smaller embryos the superior area membranacea fulfills by far the greater function but after the establishment of the lower point of fluid-passage it undergoes regressive changes. The area membranacea inferior continues to develop and function actively. It gradually forms, with increasing growth of the embryo, a caudal projection beneath the cerebellum. This inferior area in the roof gradually occupies with its differentiated ependyma the whole velum chorioidea inferior.

These results may be interpreted as affording evidence of the establishment of the circulation of cerebrospinal fluid in pig embryos of about 26 mm. The passage of this fluid from the ventricular system into the pericerebral and perispinal spaces occurred only from two localized areas in the two portions of the rhombic roof.

62. Blastolysis as a morphogenetic factor in the development of monsters. (Lantern.) E. I. WERBER, Osborn Zoological Laboratory, Yale University.

On a previous occasion I have reported some experimental results of the action of products of pathologic metabolism on the developing egg of *Fundulus heteroclitus*. It was then shown that a very great variety of monsters, similar to human and other mammalian monsters, can be produced with solutions of, particularly, two substances which are known to be present in the blood or urine of individuals suffering from disturbances of carbohydrate metabolism, namely, with butyric acid and acetone.

Although in each experiment a great diversity of morphological results has been obtained by the employment of the same method, it seems reasonable to conclude that at least some factors are common to the morphogenesis of all monsters resulting from a given experiment. A study of many deformed embryos from butyric acid and acetone solutions and analysis of existing morphological relations has, indeed, convinced me that in nearly all malformed embryos of my experiments evidence can be found of a common morphogenetic principle. For, in nearly all of them the action of some forces which tended to dissociate and destroy the germ's substance is apparent.

This action is, however, a 'complex component' in the sense of Roux, as it is probably conditioned by a number of factors present in a varying degree in individual eggs of the same experiment Analysis of these factors will for some time to come be one of the objects of my

investigations. A the present time it is the results of their collective action, to which latter I have applied the term blastolysis, that I wish to call your attention.

Blastolysis either destroys part or all of the germ's substance, or it may split off and disperse parts of the latter. The numerous meroplasts resulting from my experiments and particularly such teratomata as the 'solitary eye' and the 'isolated eye' bear ample witness to this process. The presence on the yolk of a small fragment of nervous tissue with an eye at a great distance from a malformed embryo, or even without an embryo, would, in my opinion, seem to permit of no other interpretation.

While, as we see, some effects of blastolytic action are thus strikingly evident on examination of the eggs or embryos *in toto*, other effects can be recognized only by a study of sections of them. The latter I regard as very important, for it often reveals conditions which have a significant bearing on the ontomechanics of the vertebrate organism. As we shall presently see, it also sheds light on the mode of formation of some terata, which has so far been the object of fruitless speculation.

The following are a few out of a great and constantly increasing number of facts which microscopic examination of malformed embryos may disclose. In the head region a lens may be found free, not associated with an eye, or a profusion of small lentoids may be met with, even though eyes may be entirely lacking. The complete absence of the spinal cord (amyelia) and of the notochord was noted in one embryo. That the latter condition is due to blastolytic elimination of the parts of the germ's substance which were eventually to form the spinal cord and notochord and not to an inhibition in the development of these parts would seem to be evidenced by the experience that both the spinal cord and the notochord are usually present in highly deformed embryos. Moreover, the notochord particularly, can not infrequently be found to be partially doubled—a condition indicating the action of a force which tends to dissociate parts of the early embryonic primordium (blastolysis).

Similarly, ectopia of some organs which may occasionally be found on microscopic examination of my experimental monsters would also seem to point decidedly to blastolytic action. Thus I have found in one embryo in sections through the anterior part of the head a tube-like structure which made the impression of a fragment of the intestine, while in other embryos a rudimentary eye anlage (optic vesicle) has been found on the ventral side of the posterior part of the brain, at, or beyond the level of the ear vesicles. Such findings indicate unmistakably that dissociated parts of the embryonic primordium sometimes become dislocated and are apparently capable of independent further development and differentiation in their new surroundings.

A beautiful illustration of such blastolytic dispersion of minute parts of the embryonic primordium is presented also by some monstra anophthalmica asymmetrica, on sections of which I was able to find posterior to the single lateral eye and ventrally from the brain a very

small fully differentiated fragment of an optic cup. In the latter the chorioid coat and all layers of the retina including the rods and cones-layer are at the same stage of differentiation as these parts of the single eye. The bearing of these facts is evident. For they show us the nature of the formative cause underlying the condition of single-eyedness. Thus in the case of lateral single-eyedness the potential optic anlage has been elminated by blastolytic destruction, an event which occasionally may be betrayed by a dislocated optic cup fragment, the only remnant of the anlage of the lacking eye.

In the light of our theory of blastolysis, supported by these and many other facts, the *terata of the eye,* such as cyclopia, synophthalmia and monophthalmia asymmetrica *must,* as Spemann has rightly pointed out, *be regarded as due to a defect* and not to an inhibition as has been claimed by others and notably by Dareste and by Stockard. This view is further strengthened by the condition of the brain of teratophthalmic embryos. In asymmetrically monophthalmic embryos the brain is on the side, which lacks the eye, usually distorted in its relation to the chief body axis and sometimes a dorsol-ateral part of it on the eyeless side is seen to be lacking, just as if it had been mechanically removed.

In synophthalmic and some cyclopean embryos I have always found the forebrain to be exceedingly small and unilobed, while the rest of the brain may often be apparently normal. Here, evidently, the blastolytic defect involved the potential interocular area and parts of the potential ophthalmic anlagen.

The fused olfactory pits and the proboscis-shaped mouth of such embryos (the latter due to approximation and partial fusion of the potential maxillary and mandibular arches) furnish additional evidence for the correctness of the view according to which cyclopia or synophthalmia is due to a defect.

Some experiments with acetone in which solutions of low concentrations and long exposures have been employed, have yielded results which furnish further evidence for the blastolytic defect underlying the formation of ophthalmic terata. While some of the eggs so treated have given rise to synophthamic or monophthalmic monsters, many of them have developed into embryos with two large, greatly protruding eyes. Examination of sections shows that these eyes are elongate and ovoid in shape, and it is difficult to escape the impression that during their development some forces must have been acting which tended to disrupt or disintegrate them (blastolysis). The blastolytic defect, although of a moderate degree in these cases, is strikingly exhibited by the small and wanting forebrain. Owing to this defect the eyes appear in posterior sections to be approximated. No fusion of the eyes has, however, occurred, for the part of the potential interocular area eliminated by blastolysis has not been large enough to cause a fusion of the potential eye anlgen. It could not be imagined that this approximation of the eyes is due to an inhibition which prevented the brain from pushing out the eye vesicles forwards and lateralwards, for these eyes are

in the usual lateral position in the head, from which they so grotesquely protrude. They certainly have been pushed out by the brain, and even more so than is normally the case. Their approximation is secondary and is solely due to blastolytic elimination of an intermediate part.

As we see, the morphogenesis of some deformities, like those of the eyes and of other terata finds a simple and rational explanation, if the principle of blastolysis is consistently applied in their analysis. More data in support of the correctness of this analysis and a full treatment of the subject will be found in forthcoming papers.

63. Teratogenesis of a human athorax, acephalic, acardiac triplet with numerous ageneses. Ten figures: Macroscopic, Microscopic, Photomicroscopic and Skiographic. H. O. White, Anatomical Laboratory of the College of Physicians and Surgeons, Medical Department of the University of Southern California.

Absence or maldevelopment of head.

Possible factors contributing or entirely responsible for the causation of such phenomena in the very early period of development.

Opinions entertained at present and possible errors of such opinions.

Suggestions ventured, based on our present knowledge of embryology.

Functional hyperactivity, compensatory hypertrophy, or primary developmental hyperplasia due to disturbance of normal co-ordination or possibly an intrauterine 'Developmental Neurosis,' as possible causes of agenesia of two or more like parts or organs.

Possible embryologic causes of aplasia.

Imperfect development not the cause of abnormal circulatory conditions.

Acardiaci may be caused by primary development defects, or secondary degenerations, or faulty development of one-half of a twin blastoderm, or imperfect or arrested segmentation.

Probable causes of total absence of internal genitals and presence of external in the same foetus.

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The copy of these Abstracts came in too late to have them placed in their alphabetical order.

64. The longitudinal muscle in the colon of the pig embryo. P. E. Lineback, Harvard Medical School.

For purposes of description the colon of the pig may be divided into two portions: first, that part from the valvé of the colon to the right or hepatic flexure, and second, the part from the hepatic flexure to the anus. Early in growth the first part develops a sharp 'U'-shaped coil not unlike a cochlea, making three and a half revolutions. In the 165 mm. embryo it has assumed its permanent shape.

In a pig embryo of 32 mm. there is no longitudinal muscle in the large intestine, although in the small intestine the corresponding layer is well defined.

At the 39 mm. stage the longitudinal muscle has made its appearance in the rectal region, but is not seen anywhere in the upper portion of the colon. It begins just inside the anal opening as two small bundles of fibers, flattened dorso-ventrally, located in the median line, one dorsal and the other ventral to the tube. These layers spread laterally as they are followed upward and come together at the sides of the tube about half a millimeter from the point of origin. Above this level the layer of longitudinal muscle fibers completely surrounds the intestine and extends upward about 2 mm.

In a 60 mm. pig the dense and sharply defined muscle in the lower end of the rectum has grown upward only a short distance further, but a complete circle of longitudinal fibers can now be traced downward from the ilio-caecal junction. This upper portion is loosely formed, and is evidently rapid in the downward growth, already extending several millimeters from the valve of the colon.

In an 80 mm. pig the downward growth has passed through the spiral, across the transverse colon, and a third of the way down the descending colon where it will be met by the upward growth.

At the 140 mm. stage of the longitudinal muscle is a well defined layer of fibers, completely surrounding the tube and extending throughout its entire length.

65. A cytological study of connective tissue cells of animals stained vitally with acid azo dyes. KATHERINE J. SCOTT, Department of Anatomy, University of California. (Presented by H. M. Evans.)

Goldmann's (1) description of 'Pyrrol-Zelle' and his conclusions that the staining of these cells results from the capacity of specific cell organs to react to the dye have tended to strengthen the belief of many workers that a true vital staining of cytoplasmic elments is possible. Whether or not this is due to a chemical union, as Ehrlich (2) holds, or is a physical phenomenon could not be decided from the evidence presented here. But careful cytological studies should enable us to determine whether special cytoplasmic elements are affected by these dyes. This can be settled in the case of the mitochondria. Tschaschin (3) in 1912 and later, reports a staining of the true mitochondrial elements in the fibroblasts and clasmatocytes by isamine blue and trypan blue. This observation is in contradistinction to the theory that the vital dye granules represent merely deposits of the dye, as stated by Evans and Schulemann (4).

Without going into the more theoretical aspects of the interrelations between all possible granular structures and mitochondria in these cells, we have attempted a cytological study of the vitally stained elements using the familiar methods for the identification of mitochondria.

Observations on the resting cells stained with janus green, as well as study of the reaction of these cells to varying amounts of dye and pictures during the processes of ingestion and egestion of the dye show that the respective identity of dye granules and mitochondrium is always maintained. The dye granules undergo definite changes in accordance with the functional state of the cell. Such changes in functional state may also affect the mito-chondria, as for example, in the more rounded forms met with in cell degeneration in overloading with the dye. But under no conditions are the mitochondria of connective tissue cells stained vitally with acid azo dyes.

(1) GOLDMANN, E. E. 1909, 1912 "Due äussere und innere Selarction des gesunden und kranken Organismus im Lichte der 'vitalen Furbung.'" Tübingen; Uene Untersuchungen u.s.w., "Tübingen."

(2) EHRLICH, P. 1913 'Chemio-therapy.' Address in Pathology, 7th International Congress of Medicine, British Medical Journal, August.

(3) TOCHASCHIN, S. 1912, 1913 Folia Haematologica, Bd. 14, s. 295; Bd. 16, s. 247; Bd. 17, ss. 17.

(4) EVANS AND SCHULEMANN 1913, 1914 Jahresb. d. Sch. Ges. f. vat. Kul.; Science, vol. 34, f. 443; Deut. med. Wochenschr., vol. 13.

66. On the behavior of the ovary and especially of the atretic follicle towards vital stains of the azo group. HERBERT M. EVANS, University of California.

The normal Graffian follicle of the ovary constitutes, as it were, an individual physico-chemical system for the liquor folliculi contains a higher concentration of vital dye than the tissue juices elsewhere in the ovary. This fact is peculiarly fortunate in so far as it enables us to detect the behavior towards the stain on the part of any and all of the cells concerned in the growth and atresia of the follice. Thus beginning degeneration of the granulosa cells is often marked by an abrupt change in their reaction towards the dye. Normally resistant to the entry of the dye, the degenerating cells may house large 'droplets' of the vital color so that the whole follicular epithelium is laden with it. This reaction, however, is to be separated sharply from the so-called 'macrophage' reaction, inasmuch as the granulosa cells which behave in this way show chromatolysis and other degenerative changes and are short-lived.

True macrophages play an important rôle in follicular atresia and they are electively stained by vital dyes of this class.[1] The later stages of follicular atresia are consequently marked by brilliant deposits of the vital stain due to the intense dye granules in the macrophages concerned here. The macrophages must be considered as utilizing the products of the disintegrating ovum, towards which they are attracted and which they invade by an active penetration of the zona pellucida. These are the cells first seen in this act by Pflüger and by Lindgren.

[1] The Macrophages of Mammals, Amer. Jour. Physiology, Vol. 37, No. 2, May, 1915.

DEMONSTRATIONS

1. *Cell changes in the hypophysis of the albino rat after gonadectomy.* W. H. F. Addison, University of Pennsylvania.

2. *The origin and structure of a fibrous tissue formed in wound healing.* George A. Baitsell (introduced by R. G. Harrison), Yale University.

3. *a, A brain of a hyper-ontomorph and a brain of a meso-ontomorph. b, X-ray photograph of the abdomen of a hyper-ontomorph and of a meso-ontomorph.* Robert Bennett Bean, Tulane University of Louisiana.

4. *Topographical study of the 13 mm. chick embryo.* Edward A. Boyden, Harvard Medical School, Boston, Mass.

5. *A simple type of ether thermostat for the regulation of temperature in an electric oven.* H. Saxton Burr, Anatomical Laboratory of the Yale University School of Medicine.

6. *Loose connective tissue as seat of lympho-granulopoesis.* Wera Danchakoff (introduced by W. H. Lewis), Rockefeller Institute, New York City.

7. *The effects of light on the retina of the turtle and of the lizard.* Samuel R. Detwiler (introduced by R. G. Harrison), Osborn Zoological Laboratory, Yale University.

8. *Demonstration of an unusual shape assumed by human erythrocytes.* V. E. Emmel, Washington University Medical School.

9. *An anomalous origin of the obturator artery below the inguinal ligament.* V. E. Emmel and P. L. Schroeder, Washington University Medical School.

10. *Artificial daylight for the microscope.* Simon Henry Gage, Cornell University, Ithaca, N. Y. The demonstration is to be so arranged that each observer can see the same specimen with unmodified artificial light, with artificial daylight and with true daylight.

11. *Obliterated vessels in the thymus, a possible source of thymic corpuscles.* J. F. Gudernatsch, Cornell Medical College, New York City.

12. *On the reversal of laterality in the limbs of amblystoma embryos.* Ross G. Harrison, Osborn Zoölogical Laboratory, Yale University.

13. Demonstration of dissections, cleared specimens showing the injected vascular system, and stereoscopic photographs made from dissections and injections, of albino rat embryos. CHESTER H. HEUSER, The Wistar Institute, Philadelphia.

The dissections were made of embryos which had been stained in diluted alum cochineal. In a properly stained embryo it is possible to focus a strong light upon the specimen and make dissections of very small structures under the binocular microscope. For the most careful work it is also essential to have the specimen firmly held in position; the embryo can be removed from 80 per cent alcohol, quickly rinsed in absolute and attached to a small piece of ground glass with celloidin. Embryos which are too small to be cut free hand can be split quite accurately through the sagittal plane by the following procedure. The piece of glass holding the embryo is mounted in the sliding microtome. The knife is replaced by two glass strips which extend one on either side of the embryo. The specimen is then oriented and raised between the glass strips so that the plane for sectioning coincides with the upper surface of the strips. The embryo is then covered with a few drops of celloidin. After the latter has been hardened by 80 per cent alcohol, which is allowed to drop on for a few minutes, the sectioning is done with a safety razor blade which is manipulated with the two index fingers and pushed in a see-saw movement over the glass strips. Since the embryo is not infiltrated with celloidin the cutting can not be done with one sweeping stroke of the knife. If it is desirable not to have all organs cut in the sagittal plane, a para-sagittal section can first be made; the cut surface covered with a thin layer of celloidin; and subsequent dissection done in a dish of alcohol under the microscope, using a very fine scalpel.

The study of injected embryos can be greatly facilitated by varying the method of illumination. Transmitted light is no doubt best for the majority of vessels. Strong light focused upon the specimen makes it possible to see surface vessels better, at the same time bringing out the surface markings to better advantage. A concentrated beam of light entering the specimen from the side also produces an interesting picture.

14. A demonstration of the technique of cultures of chick tissues will be made at any time (by appointment) *during or after the meeting.* E. R. HOSKINS, Zoölogy Department, Yale University (Room 221, Osborn Zoölogical Laboratories).

15. Teased preparations showing the different types of renal tubules of birds (Chicken). G. CARL HUBER, University of Michigan.

16. Teased preparations of the seminiferous tubules of birds (Chicken). G. CARL HUBER. In mammals the seminiferous tubules occur in the form of arches or systems of arches all the ends terminating in the rete testis by means of tubuli recti. No anastomoses or blind

ends are present. In the bird the seminiferous tubules branch and anastomose freely, to such extent that it has been found impossible to delimit definite tubules; the embryonic rete-cord net being maintained in the functional gland. The later disappearance of the rete-cord net in phylogeny may argue for a late disappearance of this net in mammalian ontogeny.

17. Teasedpreparations showing single, striated, voluntary muscle fibres. G. Carl Huber. Many of the voluntary fibres are of fusiform shape with fine attenuated ends.

18. An early human embryo. N. W. Ingalls, School of Medicine, Western Reserve University.

19. Specimens showing effect of inanition upon the structure of the thyroid gland. C. M. Jackson, University of Minnesota, Minneapolis, Minn.

20. Models of embryonic brains showing the relations of the neuromeres to the cerebral nerves. Franklin P. Johnson, Department of Anatomy, University of Missouri.

21. Microscopic preparations showing intercalated discs in Limulus heart muscle. H. E. Jordan, University of Virginia.

22. The prolonged gestation period in nursing mice.

23. The germ cell cycle in the mouse. W. B. Kirkham (introduced by R. G. Harrison), Osborn Zoölogical Laboratory, Yale University.

24. A quick method for preparing sections of dried bone. Frederic P. Lord, Dartmouth Medical School.

25. Tissue culture preparations. C. C. Macklin, Department of Anatomy, Johns Hopkins Medical School. Preparations will illustrate binucleate cells and amitotic nuclear division leading to their formation; also mitosis occurring in amitotic and double nuclei.

26. Models showing the development of the atrial septum and the sinus septum in pig embryos. C. V. Morrill, Cornell Medical College, New York City.

27. Artificial parthenogenesis in Cumingia. Margaret Morris (introduced by R. G. Harrison), Osborn Zoölogical Laboratory, Yale University.

28. Mounted preparations illustrating the growth of the mammary gland in the albino rat. J. A. Myers (presented by C. M. Jackson), University of Minnesota.

29. Some phases of cell mechanics. THEOPHILUS S. PAINTER (introduced by R. G. Harrison), Osborn Zoölogical Laboratory, Yale University.

30. The muscle of Breschet in birds—a possible forerunner of the tensor tympani in mammals. A. G. POHLMAN, St. Louis University.

Breschet (1836) describes a muscle or muscle rudiment in the form of a fibrous string running from the tip of the extracolumella over the drum and down the Eustachian tube. This ligament was re-discovered by Smith in 1904 and was described as an elastic ligament at the last meeting. Smith held the ligament to be inconstant because he found it in Gallus but not in Columba. Breschet describes it as constant. The writer agrees with the latter writer. It is wanting in Columba. The dissected specimens show the relations as they obtain in the pigeon, chicken, turkey, duck and goose. In the latter two mentioned, particularly in the last named, a well developed bundle of involuntary muscle fibres is added which may be followed down to the common opening of the tubes in a pad which I choose to call the Eustachian cushion. The cushion is made up largely of elastic fibres The presence of an involuntary muscle bundle in the ear of some birds and its close relation to the position of the Tensor tympani in mammals is at once suggestive of two things: 1) that the path of the Breschet muscle may be followed in the migration of the slip of the pterygoid into the middle ear region; and 2) that we may account in part for the position of the autonomic otic ganglion situated on the motor branch to the Tensor tympani muscle in a more satisfactory manner. The latter ganglion is far more complicated in its structure than usual text book description would indicate, (see sections of baby's head through this region).

31. Simple method of exposing the relations in the middle ear region. A. G. POHLMAN, St Louis University.

The method is as simple as it is complicated to describe and therefore lends itself best to demonstration. The usual mallet and chisel are used and advantage taken of the cleavage planes in the human temporal bone. The gross relations of the structures in the middle ear may be exposed by the average student in about half an hour and but ten or fifteen minutes are required in experienced hands. The methods has been used for a number of years and will be glad to show how it is done to those interested in the dissecting room.

32. Differentiation of endothelium and rhythmical cell division from studies on the living blastoderm of the chick. FLORENCE R. SABIN, Department of Anatomy, Johns Hopkins Medical School, Baltimore.

33. Photographs and microscope slides demonstrating the nerve cell changes caused by pure muscular exertion. Tamao Saito (Tokio), Phipps Psychiatric Clinic, Johns Hopkins Hospital, Baltimore, Md. (Introduced by E. V. Cowdry.)

On the right hand row of the pictures the brain (pyramidal cells of the fifth layer from the second anterior one-fifth portion of the convolution), the cerebellum (hemisphaere), the spinal cord (cells of the lateral group of the anterior horn of cervical portion) and the spinal ganglion (cells of fourth lumbal ganglion) of an experimented rat and on the left hand row the corresponding tissues from a not working animal are shown. Each section is taken in 45 and 1000 times magnifications. (Technic: alcohol fixation and carbol-thionin stain.)

The animal was put in a large basin containing water of 38°C. temperature 5 to 7½ hours every day for 7 successive days and then was set on a suspended glass rod for the rest of the time. Of the 149½ hours of the experiment he swam 50 hours and was set on the glass rod 93 hours, the remaining 6½ hours being time for feeding.

Two pairs of the microscope slides show cells of the lateral group of the lumbal cord of the experimented rats and of the not working rat, each pair being stained with the carbol-thionin resp. Cajal's method.

34a. Drawings from dissections and reconstructions illustrating the anatomy of the nasofrontal region.

34b. Photographs of new laboratory apparatus and equipment. J. Parsons Schaeffer, Daniel Baugh Institute of Anatomy and Biology of the Jefferson Medical College.

35. Accessory nerve-endings in striated muscle of Rana. H. D. Senior, New York University Medical College.

36. Model of the human lungs, trachaea, dorsal wall of pericardium, etc. B. Spector (introduced by H. D. Senior), New York University Medical College.

37. Cells of the yolk-sac and blood cells in fish embryos. Charles R. Stockard, Cornell Medical College, New York City.

38. Sections and two models to illustrate the development of the perilymphatic spaces in the internal ear of the human embryo. George L. Streeter, Carnegie Institution, Research in Embryology, Baltimore.

39. Specimens showing variations in the mitochondrial content of the cells of the nuclei of the cranial nerves. M. DeG. Thurlow (introduced by E. V. Cowdry), Anatomical Laboratory, Johns Hopkins University.

40. The position and relations of the sex gland in early human embryos. John Warren, Harvard Medical School.

41. Drawings of Fundulus monsters in toto and microscopic perparations showing evidence of blastolysis as a morphogenetic factor in the development of monsters. E. I. Werber, Osborn Zoölogical Laboratory, Yale University.

42. Studies on cell lamination in the cortex of the sheep. Charles Bagley, Jr. (introduced by E. V. Cowdry), Neurological Laboratory, Phipps Psychiatric Clinic, Johns Hopkins Hospital.

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Bigelow, Robert P., Ph.D., Assistant Professor of Zoölogy and Parasitology, *Massachusetts Institute of Technology, Boston, Mass.*

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Browning, William, Ph.D., M.D., Professor of Nervous and Mental Diseases, Long Island College Hospital, *54 Lefferts Place, Brooklyn, N. Y.*

Bryce, Thomas H., M.A., M.D., Regius Professor of Anatomy, University of Glasgow, No. 2, *The University, Glasgow, Scotland.*

Bullard, H. Hays, A.M., Ph.D., *Johns Hopkins Medical School, Baltimore, Md.*

Bunting, Charles Henry, B.S., M.D., Professor of Pathology, *University of Wisconsin, 2020 Chadbourne Avenue, Madison, Wis.*

Burr, Harold Saxton, Ph.B., Ph.D., Instructor in Anatomy, School of Medicine, *Yale University, New Haven, Conn.*

Burrows, Montrose T., A.B., M.D., Acting Resident Pathologist, *Johns Hopkins Hospital, Baltimore, Md.*

Campbell, William Francis, A.B., M.D., Professor of Anatomy and Histology, Long Island College Hospital, *394 Clinton Avenue, Brooklyn, N. Y.*

Carpenter, Frederick Walton, Ph.D., Professor of Zoölogy, *Trinity College, Hartford, Conn.*

Casamajor, Louis, B.A., M.D., Assistant Professor of Neurology, Columbia University, *437 West 59th Street, New York City.*

Chambers, Robert, Jr., A.M., Ph.D., Assistant in Anatomy, *Cornell University Medical College, New York City.*

Cheever, David, A.B., M.D., Assistant Professor of Surgical Anatomy, Harvard Medical School, *20 Hereford Street, Boston, Mass.*

Chidester, Floyd E., A.M., Ph.D., Associate Professor of Zoölogy, *Rutgers College, New Brunswick, N. J.*

Child, Charles Manning, Ph.D., Associate Professor of Zoölogy, *University of Chicago, Chicago, Ill.*

Chillingworth, Felix P., M.D., Assistant Professor of Physiology and Pharmacology, *Tulane University, New Orleans, La.*

Clapp, Cornelia Maria, Ph.D., Professor of Zoölogy, *Mount Holyoke College, South Hadley, Mass.*

Clark, Elbert, B.S., Instructor in Anatomy, *University of Chicago, Chicago, Ill.*

Clark, Eleanor Linton, A.M., Research Worker, Department of Anatomy, *University of Missouri, Columbia, Mo.*

Clark, Eliot R., A.B., M.D., Professor of Anatomy, *University of Missouri, 406 S. 9th Street, Columbia, Mo.*

Coe, Wesley R., Ph.D., Professor of Biology, *Sheffield Scientific School, Yale University, New Haven, Conn.*

Coghill, George E., Ph.D., Associate Professor of Anatomy, University of Kansas Medical School, *338 Illinois Street, Lawrence, Kans.*

Cohn, Alfred E., M.D., Associate in Medicine, Rockefeller Institute for Medical Research, *315 Central Park West, New York, N. Y.*

Cohoe, Benson A., A.B., M.B., Associate Professor of Therapeutics, University of Pittsburgh, *705 North Highland Avenue, Pittsburgh, Pa.*

Conant, William Merritt, M.D., Professor of Clinical Surgery, Tufts Medical School, *486 Commonwealth Avenue, Boston, Mass.*

Congdon, Edgar Davidson, Ph.D., Assistant Professor of Anatomy, Leland Stanford University, School of Medicine, *330 Coleridge Avenue, Palo Alto, Calif.*

Conklin, Edwin Grant, A.M., Ph.D., Sc.D., Professor of Biology, Princeton University, *139 Broadmead Avenue, Princeton, N. J.*

Corner, George W., A.B., M.D., Assistant Professor of Anatomy, *Anatomical Laboratory, Berkeley, Calif.*

Corning, H. K., M.D., Professor of Anatomy, *Bündesstr. 17, Basel, Switzerland.*

Corson, Eugene Rollin, B.S., M.D., Surgeon, Lecturer on Anatomy, Savannah Hospital Training School for Nurses, *10 Jones Street, West, Savannah, Ga.*

Cowdry, Edmund V., Ph.D., Associate in Anatomy, Anatomical Laboratory, *Johns Hopkins Medical School, Baltimore, Md.*

Craig, Joseph David, A.M., M.D., *12 Ten Broeck Street, Albany, N. Y.*

Crile, George W., A.M., M.D., Professor of Surgery, Western Reserve University, *222 Osborn Bldg., Cleveland, O.*

Cullen, Thomas S., M.D., *20 E. Eager Street, Baltimore, Md.*

Cunningham, Robert S., B.S., A.M., Johns Hopkins Medical School, *716 N. Broadway, Baltimore, Md.*

Curtis, George M., A.B., A.M., Acting Professor of Anatomy, Medical Department of the Vanderbilt University, *1047 South 3rd Avenue, Nashville, Tenn.*

Dahlgren, Ulric, A.B., M.S., Professor of Biology, Princeton University, *204 Guyot Hall, Princeton, N. J.*

Danchakoff, Wera, M.D., *Rockefeller Institute, New York City.*

Danforth, Charles Haskell, A.M., Ph.D., Associate in Anatomy, Medical Department, *Washington University Medical School, St. Louis, Mo.*

Darrach, William, A.M., M.D., Assistant Attending Surgeon, Presbyterian Hospital, Instructor in Clinical Surgery, Columbia University, *47 West 50th Street, New York, N. Y.*

Davis, David M., B.S., *Johns Hopkins Medical School, Baltimore, Md.*

Davis, Henry K., A.B., A.M., Instructor in Anatomy, *Cornell University Medical College, Ithaca, N. Y.*

Dean, Bashford, Ph.D., Professor of Vertebrate Zoölogy, Columbia University, Curator of Fishes and Reptiles, American Museum Natural History, *Riverdale-on-Hudson, New York.*

Detwiler, Samuel Randall, Ph.D., Assistant in Biology, *Yale University, New Haven, Conn.*

Dexter, Franklin, M.D., *247 Marlborough Street, Boston, Mass.*

Dixon, A. Francis, M.B., Sc.D., University Professor of Anatomy, Trinity College, *73 Grosvenor Road, Dublin, Ireland.*

Dodson, John Milton, A.M., M.D., Dean and Professor of Medicine, Rush Medical College, University of Chicago, *5806 Blackston Avenue, Chicago, Ill.*

Dolley, D. H., M.D., Professor of Pathology, *University of Missouri, Columbia, Mo.*

Donaldson, Henry Herbert, Ph.D., D.Sc., (Ex. Com. '09–'13), Professor of Neurology, *The Wistar Institute of Anatomy and Biology, Woodland Avenue and 36th Street, Philadelphia, Pa.*

Downey, Hal, M.A., Ph.D., Associate Professor of Histology, *Department of Animal Biology, University of Minnesota, Minneapolis, Minn.*

Duesberg, Jules, M.D., Research Associate, Carnegie Institution of Washington, *Johns Hopkins Medical School, Baltimore, Md.*

Dunn, Elizabeth Hopkins, A.M., M.D., *Marine Biological Laboratory, Woods Hole, Mass.*

Eccles, Robert G., M.D., Phar.D., *681 Tenth Street, Brooklyn, N. Y.*

Edwards, Charles Lincoln, Ph.D., Director of Nature Study, Los Angeles City Schools, *1032 West 39th Place, Los Angeles, Calif.*

Eggerth, Arnold Henry, Assistant in Histology and Embryology, *University of Michigan, 1324 Volland Avenue, Ann Arbor, Michigan.*

Elliot, Gilbert M., A.M., M.D., Assistant Professor and Demonstrator of Anatomy, Medical School of Maine, *152 Maine Street, Brunswick, Me.*

Emmel, Victor E., M.S., Ph.D., Assistant Professor of Anatomy, University of Illinois College of Medicine, *Congress and Honore Streets, Chicago, Ill.*

Essick, Charles Rhein, B.A., M.D., *1807 North Caroline Street, Baltimore, Md.*

Evans, Herbert McLean, B.S., M.D., Professor of Anatomy, *University of California, Berkeley, Calif.*

Evatt, Evelyn John, B.S., M.B., Professor of Anatomy, *Royal College of Surgeons, Dublin, Ireland.*

Eycleshymer, Albert Chauncey, Ph.D., M.D., Professor of Anatomy, *Medical Department, University of Illinois, Honore and Congress Streets, Chicago, Ill.*

Ferris, Harry Burr, A.B., M.D., Hunt Professor of Anatomy and Head of the Department of Anatomy, Medical Department, Yale University, *395 St. Ronan Street, New Haven, Conn.*

Fetterolf, George, A.B., M.D., Sc.D., Assistant Professor of Anatomy, University of Pennsylvania, *330 South 16th Street, Philadelphia, Pa.*

Fischelis, Philip, M.D., Associate Professor of Histology and Embryology, Medico-Chirurgical College, *828 North 5th Street, Philadelphia, Pa.*

Flint, Joseph Marshall, B.S., A.M., M.D. (Second Vice-Pres. '00–'04), Professor of Surgery, Yale University, *320 Temple Street, New Haven, Conn.*

Frost, Gilman Dubois, A.M., M.D., Professor of Clinical Medicine, *Dartmouth Medical School, Hanover, N. H.*

Gage, Simon Henry, B.S. (Ex. Com. '06–'11), Emeritus Professor of Histology and Embryology, *Cornell University, 4 South Avenue, Ithaca, N. Y.*

Gallaudet, Bern Budd, A.M., M.D., Assistant Professor of Anatomy, Columbia University, Consulting Surgeon Bellevue Hospital, *110 East 16th Street, New York, N. Y.*

Geddes, A. Campbell, M.D., M.B., Ch.B., F.R.S.E., Professor of Anatomy, *McGill University, Montreal, Canada.*

GIBSON, JAMES A., M.D., Professor of Anatomy, Medical Department, University of Buffalo, *24 High Street, Buffalo, N. Y.*

GILMAN, PHILIP KINGSWORTH, B.A., M.D., Professor of Surgery, University of Philippines, *Suite 417–427 Kneedler Bldg., Manila, P. I.*

GLOBUS, J. H., B.A., Assistant in Anatomy, *Cornell University Medical College, New York City.*

GOETSCH, EMIL, Ph.D., M.D., Associate in Surgery, *Johns Hopkins Hospital, Baltimore, Md.*

GREENE, CHARLES W., A.M., Ph.D., Professor of Physiology and Pharmacology, *University of Missouri, 814 Virginia Avenue, Columbia, Mo.*

GREENMAN, MILTON J., Ph.B., M.D., Sc.D., Director of *The Wistar Institute of Anatomy and Biology, 36th Street and Woodland Avenue, Philadelphia, Pa.*

GUDERNATSCH, J. F., Ph.D., Assistant Professor of Anatomy, *Cornell University Medical College, New York City.*

GUILD, STACY R., A.M., Instructor in Histology and Embryology, University of Michigan, *1511 Washtenaw Avenue, Ann Arbor, Mich.*

GUYER, MICHAEL F., Ph.D., Professor of Zoölogy, University of Wisconsin, *138 Prospect Avenue, Madison, Wis.*

HALSTED, WILLIAM STEWART, M.D., Professor of Surgery, Johns Hopkins University, *1201 Eutaw Place, Baltimore, Md.*

HAMANN, CARL A., M.D. (Ex. Com. '02–'04), Professor of Applied Anatomy and Clinical Surgery, Western Reserve University, *416 Osborn Building, Cleveland, Ohio.*

HARDESTY, IRVING, A.B., Ph.D. (Ex. Com. '10 and '12–'15), Professor of Anatomy and head of Department of Anatomy, *Tulane University of Louisiana, Station 20, New Orleans, La.*

HARE, EARL R., A.B., M.D., Instructor in Surgery, University of Minnesota, *623 Syndicate Building, Minneapolis, Minn.*

HARRISON, ROSS GRANVILLE, Ph.D., M.D. (Pres. '12–'13), Bronson Professor of Comparative Anatomy, *Yale University, New Haven, Conn.*

HARVEY, BASIL COLEMAN HYATT, A.B., M.B., Associate Professor of Anatomy, University of Chicago, *Department of Anatomy, University of Chicago, Chicago, Ill.*

HARVEY, RICHARD WARREN, M.S., M.D., Assistant Professor of Anatomy, Anatomy Department, *University of California, Berkeley, Calif.*

HATAI, SHINKISHI, Ph.D., Associate in Neurology, *Wistar Institute of Anatomy and Biology, Philadelphia, Pa.*

HATHAWAY, JOSEPH H., A.M., M.D., Professor of Anatomy, Anatomical Department, *Detroit Medical College, Detroit, Mich.*

HAZEN, CHARLES MORSE, A.M., M.D., Professor of Physiology, *Medical College of Virginia, Richmond, Bon Air, Va.*

HEAGEY, FRANCIS WENGER, A.B., M.D., Instructor in Anatomy, Columbia University, *437 West 59th Street, New York City.*

HEISLER, JOHN C., M.D., Professor of Anatomy, Medico-Chirurgical College, *3829 Walnut Street, Philadelphia, Pa.*

HELDT, THOMAS JOHANES, A.B., A.M., *200 East Lanvale Street, Baltimore, Md.*

HERRICK, CHARLES JUDSON, Ph.D. (Ex. Com. '13–) Professor of Neurology, University of Chicago, *Laboratory of Anatomy, University of Chicago, Chicago, Ill.*

HERTZLER, ARTHUR E., M.D., F.A.C.S., Associate in Surgery, University of Kansas, *1004 Rialto Building, Kansas City, Mo.*

HERZOG, MAXIMILIAN, M.D., Professor of Pathology and Bacteriology, La Gola University, *1358 Fulton Street, Chicago, Ill.*

HEUSER, CHESTER H., A.M., Ph.D., Fellow in Anatomy, *Wistar Institute of Anatomy, 36th Street and Woodland Avenue, Philadelphia, Pa.*

HEWSON, ADDINELL, A.M., M.D., Professor of Anatomy, Philadelphia Polyclinic for Graduates in Medicine, *2120 Spruce Street, Philadelphia, Pa.*

HILL, HOWARD, M.D., *1010 Rialto Building, Kansas City, Mo.*

HILL, JAMES PETER, D.Sc., F.R.S., Todrell Professor of Zoölogy and Comparative Anatomy, University of London, *University College, Gower Street, London, W.C., England.*

HILTON, WILLIAM A., Ph.D., Professor of Zoölogy, *Pomona College, Claremont, Calif.*

HOEVE, HUBERTUS H. J., M.D., *Hoeve Hospital, Meherrin, Virginia.*

HOOKER, DAVENPORT, M.A., Ph.D., Assistant Professor of Anatomy, *Yale Medical School, New Haven, Conn.*

HOPEWELL-SMITH, ARTHUR, L.R.C.P., M.R.C.S., L.D.S., Professor of Dental Histology, Histo-Pathology, Comparative Odontology, *University of Pennsylvania Dental College, Philadelphia, Pa.*

HOPKINS, GRANT SHERMAN, Sc.D., D.V.M., Professor of Veterinary Anatomy, *Cornell University, Ithaca, N. Y.*

HOSKINS, ELMER R., A.B., A.M., Assistant in Biology, Yale University, *Osborne Zoölogical Laboratory, New Haven, Conn.*

HRDLIČKA, ALES, M.D., Curator of the Division of Physical Anthropology, *United States National Museum, Washington, D. C.*

HUBER, G. CARL, M.D. (Second Vice-Pres. '00–'01, Secretary-Treasurer '02–'13, Pres. '14–'15) Professor of Anatomy and Director of the Anatomical Laboratories, University of Michigan, *1330 Hill Street, Ann Arbor, Mich.*

HUNTINGTON, GEORGE S., A.M., M.D., D.Sc., LL.D. (Ex. Com. '95–'97, '04–'07, Pres. '99–'03), Professor of Anatomy, Columbia University, *437 West 59th Street, New York, N. Y.*

INGALLS, N. WILLIAM, M.D., Associate Professor of Anatomy, *Medical College, Western Reserve University, Cleveland, Ohio.*

JACKSON, CLARENCE M., M.S., M.D. (Ex. Com. '10–'14), Professor and Head of the Department of Anatomy, *University of Minnesota, Institute of Anatomy, Minneapolis, Minn.*

JENKINS, GEORGE B., M.D., Professor of Anatomy, *Department of Anatomy, University of Louisville, Louisville, Ky.*

JOHNSON, CHARLES EUGENE, A.M., Ph.D., Instructor in Comparative Anatomy of Vertebrates, *Department of Animal Biology, University of Minnesota, Minneapolis, Minn.*

JOHNSON, FRANKLIN P., A.M., Ph.D., Associate Professor of Anatomy, *University of Missouri, 408 South Ninth Street, Columbia, Mo.*

JOHNSTON, JOHN B., Ph.D., Professor of Comparative Neurology, *University of Minnesota, Minneapolis, Minn.*

JORDAN, HARVEY ERNEST, Ph.D., Professor of Histology and Embryology, *University of Virginia, University, Va.*

KAMPMEIER, OTTO FREDERICK, A.B., Ph.D., Assistant Professor of Embryology and Comparative Embryology, *University of Pittsburgh, School of Medicine, Pittsburgh, Pa.*

KAPPERS, CORNELIUS UBBO ARIENS, Director of the *Central Institute for Brain Research of Holland, Mauritskade 61, Amsterdam, Holland.*

KEILLER, WILLIAM, L.R.C.P. and F.R.C.S.Ed. (Second Vice-Pres. '98–'99), Professor of Anatomy, Medical Department University of Texas, *State Medical College, Galveston, Texas.*

KEITH, ARTHUR, M.D., LL.D., F.R.C.S., F.R.S., Hunterian Professor of Anatomy, *College of Surgeons, London, England.*

KELLY, HOWARD ATWOOD, A.B., M.D., LL.D., Professor of Gynecology, Johns Hopkins University, *1418 Eutaw Place, Baltimore, Md.*

KERNAN, JOHN D., JR., A.B., M.D., Assistant in Anatomy, Columbia University, *437 West 59th Street, New York City.*

KERR, ABRAM T., B.S., M.D. (Ex. Com. '10–'14), Professor of Anatomy, *Cornell University Medical College, Ithaca, N. Y.*

KEY, J. A., B.S., Instructor in Anatomy, *Creighton Medical College, Omaha, Neb.*

KINGERY, HUGH MCMILLAN, A.M., Instructor in Histology and Embryology, *Cornell University, Ithaca, N. Y.*

KINGSBURY BENJAMIN F., Ph.D., M.D., Professor of Histology and Embryology, Cornell University, *802 University Avenue, Ithaca, N. Y.*

KINGSLEY, JOHN STERLING, Sc.D., Professor of Zoölogy, *University of Illinois, Urbana, Ill.*

KING, HELEN DEAN, A.B., Ph.D., Assistant Professor of Embryology, *Wistar Institute of Anatomy, 36th Street and Woodland Avenue, Philadelphia, Pa.*

KIRKHAM, WILLIAM BARRI, Ph.D., Instructor in Biology, *Sheffield Scientific School, Yale University, New Haven, Conn.*

KNOWER, HENRY MCE., A.B., Ph.D. (Ex. Com. '11–'15), Professor of Anatomy, *Medical Department, University of Cincinnati, Station V, Cincinnati, Ohio.*

KOFOID, CHARLES ATWOOD, Ph.D., Professor of Zoölogy, University of California, Assistant Director San Diego Marine Biological Station, *2616 Etna Street, Berkeley, Calif.*

KUNKEL, BEVERLY WAUGH, Ph.B., Ph.D., Professor of Zoölogy, *Lafayette College, Easton, Pa.*

KUNTZ, ALBERT, Ph.D., Assistant Professor of Histology and Biology, Department of Anatomy, University of St. Louis, *3911 Castleman Avenue, St. Louis, Mo.*

KUTCHIN, HARRIET LEHMANN, A.M., *"The Maplewood," Green Lake, Wisconsin.*

KYES, PRESTON, A.M., M.D., Assistant Professor of Experimental Pathology, *Department of Pathology, University of Chicago, Chicago, Ill.*

LAMB, DANIEL SMITH, A.M., M.D., LL.D. (Secretary-Treasurer '90–'01, Vice-Pres. '02–'03) Pathologist Army Medical Museum, Professor of Anatomy, Howard University, Medical Department, *2114 18th Street, N. W., Washington, D. C.*

LAMBERT, ADRIAN V. S., A.B., M.D., Associate Professor of Surgery, Columbia University, *168 East 71st Street, New York, N. Y.*

LANDACRE, FRANCIS LEROY, A.B., Ph.D., Professor of Anatomy, Ohio State University, *2026 Inka Avenue, Columbus, Ohio.*

Lane, Michael Andrew, B.S., *122 S. California Avenue, Chicago, Ill.*

Laurens, Henry, Ph.D., Instructor in Biology, *Yale University, New Haven, Conn.*

Lee, Thomas G., B.S., M.D. (Ex. Com. '08–'10, Vice Pres. '12–'13), Professor of Comparative Anatomy, University of Minnesota, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

Leidy, Joseph, Jr., A.M., M.D., *1319 Locust Street, Philadelphia, Pa.*

Lewis, Dean D., M.D., Assistant Professor of Surgery, Rush Medical College, *People's Gas Building, Chicago, Ill.*

Lewis, Frederic T., A.M., M.D. (Ex. Com. '09–'13, Vice-Pres. '14–), Assistant Professor of Embryology, *Harvard Medical School, Boston, Mass.*

Lewis, Warren Harmon, B.S., M.D. (Ex. Com. '09–'11, '14–), Professor of Physiological Anatomy, *Johns Hopkins University, Medical School, Baltimore, Md.*

Lillie, Frank Rathay, Ph.D., Professor of Embryology, Chairman of Department of Zoölogy, University of Chicago; Director Marine Biological Laboratory, Woods Hole, Mass., *University of Chicago, Chicago, Ill.*

Lineback, Paul Eugene, A.B., M.D., Teaching Fellow in Histology and Embryology, *Harvard Medical School, Boston, Mass.*

Locy, William A., Ph.D., Sc.D., Professor of Zoölogy and Director of the Zoölogical Laboratory, Northwestern University, *1745 Orrington Avenue, Evanston, Ill.*

Loeb, Hanau Wolf, A.M., M.D., Professor and Director of the Department of the Diseases of the Ear, Nose and Throat, St. Louis University, *537 North Grand Avenue, St. Louis, Mo.*

Lord, Frederic P., A.B., M.D., Professor of Anatomy and Histology, *Dartmouth Medical School, Hanover, N. H.*

Lowrey, Lawson Gentry, A.M., Fellow in Neuropathology, Harvard Medical School; Pathologist, *Danvers State Hospital, Hawthorne, Mass.*

Macklin, C. C., M.B., Assistant in Anatomy, Department of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

McCarthy, John George, M.D., Formerly Assistant Professor of Anatomy, McGill University, *112 St. Mark Street, Montreal, Canada.*

McClung, Clarence E., A.M., Ph.D., Professor of Zoölogy, *University of Pennsylvania, Philadelphia, Pa.*

McClure, Charles Freeman Williams, A.M., Sc.D. (Vice-Pres. '10–'11. Ex. Com. '12–'16), Professor of Comparative Anatomy, *Princeton University, Princeton, N. J.*

McCormack, William Eli, M.D., Instructor in Embryology and Histology, University of Louisville, Medical Department, *101 W. Chestnut Street, Louisville, Ky.*

McCotter, Rollo E., M.D., Professor of Anatomy, Medical Department, University of Michigan, *809 E. University Avenue, Ann Arbor, Mich.*

McFarland, Frank Mace, Ph.D., Professor of Histology, *Leland Stanford Junior University, 2 Cabrillo Avenue, Stanford, Calif.*

McGill, Caroline, A.M., Ph.D., M.D., Pathologist, *Murray Hospital, Butte, Mont.*

McKibben, Paul S., Ph.D., Professor of Anatomy, *Department of Anatomy, Western University, London, Ontario, Canada.*

McMurrich, James Playfair, A.M., Ph.D., LL.D. (Ex. Com. '06–'07, Pres. '08–'09), Professor of Anatomy, University of Toronto, *75 Forest Hill Road, Toronto, Canada.*

McWhorter, John E., M.D., Worker under George Crocker Research Fund, College of Physicians and Surgeons, Columbia University, *205 West 107th Street, New York, N. Y.*

Mall, Franklin P., A.M., M.D., LL.D., D.Sc. (Ex. Com. '00–'05, Pres. '06–'07), Professor of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

Mangum, Charles S., A.B., M.D., Professor of Anatomy, *University of North Carolina, Chapel Hill, N. C.*

Malone, Edward Fall, A.B., M.D., Assistant Professor of Anatomy, *University of Cincinnati, College of Medicine, Station V, Cincinnati, Ohio.*

Mark, Edward Laurens, Ph.D., LL.D., Hersey Professor of Anatomy and Director of the Zoölogical Laboratory, Harvard University, *109 Irving Street, Cambridge, Mass.*

Matas, Rudolph, M.D., Professor of Surgery, Tulane University, *2255 St. Charles Avenue, New Orleans, La.*

Maximow, Alexander, M.D., Professor of Histology and Embryology at the Imperial Military Academy of Medicine, Petrograd, Russia, *Botkinskaja 2, Petrograd, Russia.*

Mellus, Edward Lindon, M.D., *12 Fuller Street, Brookline, Mass.*

Mercer, William F., Ph.M., Ph.D., Professor of Biology, Ohio University, *Box 384, Athens, Ohio.*

Metheny, D. Gregg, M.D., L.R.C.R., L.R.C.S., Edin.—L.F.P.S., Glasg., Associate in Anatomy, *Jefferson Medical College, 11th and Clinton Streets, Philadelphia, Pa.*

Meyer, Adolf, M.D., LL.D., Professor of Psychiatry and Director of the Henry Phipps Psychiatric Clinic, *Johns Hopkins Hospital, Baltimore, Md.*

Meyer, Arthur W., S.B., M.D. (Ex. Com. '12–'16), Professor of Anatomy, Leland Stanford Junior University, *Stanford University, Calif.*

Miller, Adam M., A.M., Professor of Anatomy, Long Island College Hospital, *Henry and Amity Streets, Brooklyn, N. Y.*

Miller, M. M., Ph.D., Instructor in Anatomy, *Vanderbilt University Medical School, Nashville, Tenn.*

Miller, William Snow, M.D. (Vice-Pres. '08–'09), Associate Professor of Anatomy, University of Wisconsin, *2001 Jefferson Street, Madison, Wis.*

Mixter, Samuel Jason, B.S., M.D., Visiting Surgeon Massachusetts General Hospital, *180 Marlboro Street, Boston, Mass.*

Moodie, Roy L., A.B., Ph.D., Instructor in Anatomy, *University of Illinois Medical College, Congress and Honore Streets, Chicago, Ill.*

Moody, Robert Orten, B.S., M.D., Associate Professor of Anatomy, University of California, *2826 Garber Street, Berkeley, Calif.*

Morrill, Charles V., A.M., Ph.D., Instructor in Anatomy, *Cornell University Medical School, 1st Avenue and 28th Street, New York, N. Y.*

Muller, Henry R., A.B., M.D., Assistant in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

Munson, John P., Ph.D., Head of the Department of Biology, Washington State Normal School, *706 North Anderson Street, Ellensburg, Washington.*

MURPHEY, HOWARD S., D.V.M., Professor of Anatomy and Histology, *519 Welch Avenue, Station A, Ames, Ia.*

MYERS, BURTON D., A.M., M.D., Professor of Anatomy and Secretary of the Indiana University School of Medicine, *Indiana University, Bloomington, Ind.*

MYERS, JAY A., M.S., Ph.D., Instructor in Anatomy, *University of Minnesota, 624 University Avenue, S. E., Minneapolis, Minn.*

MYERS, MAE LICHTENWALNER, M.D., Associate Professor of Anatomy and Director of the Laboratories of Histology and Embryology, *Woman's Medical College of Pennsylvania, North College Avenue and 21st Street, Philadelphia, Pa.*

NACHTRIEB, HENRY FRANCIS, B.S., Professor of Animal Biology and Head of the Department, University of Minnesota, *905 East 6th Street, S.E., Minneapolis, Minn.*

NEAL, HERBERT VINCENT, Ph.D., Professor of Zoölogy, Tufts College, *Tufts College, Mass.*

NOBLE, HARRIET ISABEL, *262 Putnam Avenue, Brooklyn, N. Y.*

NORRIS, H. W., A.B., Professor of Zoölogy, *Grinnell College, Grinnell, Iowa.*

PAINTER, THEOPHILUS S., Ph.D., Instructor in Biology, *Sheffield Scientific School, Yale University, New Haven, Conn.*

PAPANICOLAOU, GEORGE, Ph.D., M.D., Assistant in Anatomy, *Cornell University Medical College, New York City.*

PAPEZ, JAMES WENCESLAS, B.A., M.D., Professor of Anatomy, Histology and Embryology, *Atlanta Medical College, 94 Butler Street, Atlanta, Ga.*

PARKER, GEORGE HOWARD, D.Sc., Professor of Zoölogy, Harvard University, *16 Berkeley Street, Cambridge, Mass.*

PATON, STEWART, A.B., M.D., Lecturer in Biology, *Princeton University, Princeton, N. J.*

PATTEN, WILLIAM, Ph.D., Professor of Zoölogy, *Dartmouth College, Hanover, N. H.*

PATERSON, A. MELVILLE, M.D., F.R.C.S., Professor of Anatomy, *University of Liverpool, Liverpool, England.*

PATTERSON, JOHN THOMAS, Ph.D., Professor and Chairman of the School of Zoölogy, University of Texas, *University Station, Austin, Texas.*

PIERSOL, GEORGE A., M.D., Sc.D. (Vice-Pres. '93–'94, '98–'99, '06–'07, Pres. '10–'11), Professor of Anatomy, University of Pennsylvania, *4724 Chester Avenue, Philadelphia, Pa.*

PIERSOL, WILLIAM HUNTER, A.B., M.B., Associate Professor of Histology and Embryology, *Biological Department, University of Toronto, Toronto, Canada.*

POHLMAN, AUGUSTUS G., M.D., Professor of Anatomy, *Medical Department, University of St. Louis, 1402 South Grand Avenue, St. Louis, Mo.*

POTTER, PETER, M.S., M.D., Oculist and Aurist, Murray Hospital, Butte, Montana, *411–413 Hennessy Building, Butte, Montana.*

POYNTER, CHARLES W. M., B.S., M.D., Professor of Anatomy, *College of Medicine, University of Nebraska, Omaha, Neb.*

PRENTISS, H. J., M.D., M.E., Professor of Anatomy, University of Iowa, *Iowa City, Iowa.*

PRYOR, JOSEPH WILLIAM, M.D., Professor of Anatomy and Physiology, State College of Kentucky, *261 North Broadway, Lexington, Ky.*

RADASCH, HENRY E., M.S., M.D., Assistant Professor of Histology and Embryology, Jefferson Medical College, *Daniel Baugh Institute of Anatomy, 11th and Clinton Streets, Philadelphia, Pa.*

RANSON, STEPHEN W., M.D., Ph.D., Professor of Anatomy, Northwestern University Medical School, *2431 Dearborn Street, Chicago, Ill.*

REAGAN, FRANKLIN P., A.B., *Princeton University, Princeton, N. J.*

REED, HUGH DANIEL, Ph.D., Assistant Professor of Zoölogy, Cornell University, *108 Brandon Place, Ithaca, N. Y.*

REESE, ALBERT MOORE, A.B., Ph.D., Professor of Zoölogy, *West Virginia University, Morgantown, W. Va.*

RETZER, ROBERT, M.D., Professor of Anatomy and Dean, *Creighton College of Medicine, Omaha, Neb.*

REVELL, DANIEL GRAISBERRY, A.B., M.B., Professor of Anatomy, University of Alberta, *Strathcona Post Office, Edmonton South, Alberta, Canada.*

RHINEHART, D. A., M.D., Professor of Anatomy, University of Arkansas, *Old State House, Little Rock. Ark.*

RICE, EDWARD LORANUS, Ph.D., Professor of Zoölogy, *Ohio Wesleyan University, Delaware, Ohio.*

ROBINSON, ARTHUR, M.D., F.R.C.S. (Edinburgh), Professor of Anatomy, University of Edinburgh, *The University, Edinburgh, Scotland.*

RUTH, EDWARD S., M.D., Assistant Professor of Anatomy, *University of the Philippines, College of Medicine and Surgery, Manila, P. I.*

SABIN, FLORENCE R., B.S., M.D. (Second Vice-Pres. '08 '09), Associate Professor of Anatomy, *Johns Hopkins University, Medical Department, Baltimore, Md.*

SANTEE, HARRIS E., A.M., Ph.D., M.D., Professor of Anatomy, Jenner Medical College, and Professor of Neural Anatomy, Chicago College of Medicine and Surgery, *2806 Warren Avenue, Chicago, Ill.*

SCAMMON, RICHARD E., Ph.D., Professor of Anatomy, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

SCHAEFER, MARIE CHARLOTTE, M.D., Associate Professor of Biology, Histology and Embryology, *Medical Department, University of Texas, 701 North Pine Street, San Antonio, Texas.*

SCHAEFFER, JACOB PARSONS, A.M., M.D., Ph.D., Professor of Anatomy, *Jefferson Medical College, 11th and Clinton Streets, Philadelphia, Pa.*

SCHOCHET, SIDNEY SIGSFRIED, M.D., Instructor in Anatomy, *Dartmouth Medical School, Hanover, N. H.*

SCHOEMAKER, DANIEL M., B.S., M.D., Professor of Anatomy, Medical Department, St. Louis University, *1402 South Grand Avenue, St. Louis, Mo.*

SCHULTE, HERMANN VON W., A.B., M.D. (Ex. Com. '15) Associate Professor of Anatomy, Columbia University, *437 West 59th Street, New York, N. Y.*

SCHMITTER, FERDINAND, A.B., M.D., *Captain Medical Corps, U. S. Army, Columbus Barracks, Columbus, Ohio.*

SCOTT, JOHN W., A.M., Ph.D., Professor of Zoölogy, *University of Wyoming, Laramie, Wyo.*

SCOTT, KATHERINE JULIA, A.B., M.D., Assistant in Anatomy, *University of California, Berkeley, Calif.*

SEELIG, MAJOR G., A.B., M.D., Professor of Surgery, St. Louis University, *Humboldt Building, 537 North Grand Avenue, St. Louis, Mo.*

SELLING, LAWRENCE, A.B., M.D., *Selling Building, Portland, Ore.*

SENIOR, HAROLD D., M.B., D.Sc., F.R.C.S., Professor of Anatomy, New York University, University and Bellevue Hospital Medical College, *338 East 26th Street, New York, N. Y.*

SHELDON, RALPH EDWARD, A.M., M.S., Ph.D., Professor of Anatomy, *University of Pittsburgh Medical School, Grant Boulevard, Pittsburgh, Pa.*

SHIELDS, RANDOLPH TUCKER, A.B., M.D., Dean, *University of Nanking Medical School, Nanking, China.*

SHUFELDT, R. W., M.D., Major Medical Corps, U. S. A. (Retired), *3356 Eighteenth Street, N. W., Washington, D. C.*

SILVESTER, CHARLES FREDERICK, Curator of the Zoölogical Museum and Assistant in Anatomy, Princeton University, *10 Nassau Hall, Princeton, N. J.*

SIMPSON, SUTHERLAND, M.D., D.Sc., F.R.S.E. (Edin.), Professor of Physiology, *Cornell University Medical College, Ithaca, N. Y.*

SISSON, SEPTIMUS, B.S., V.S., Professor of Comparative Anatomy, Ohio State University, *274 14th Avenue, Columbus, Ohio.*

SLUDER, GREENFIELD, M.D., Clinical Professor of Laryngology, Washington University Medical School, *3542 Washington Avenue, St. Louis, Mo.*

SMITH, CHARLES DENNISON, A.M., M.D., Superintendent Maine General Hospital Professor of Physiology, Medical School of Maine, *Maine General Hospital, Portland, Me.*

SMITH, GEORGE MILTON, A.B., M.D., Associate in Pathology, *Washington University Medical School, St. Louis, Mo.*

SMITH, GRAFTON ELLIOT, M.A., M.D., F.R.S., Professor of Anatomy, *The University, Manchester, England.*

SMITH, J. HOLMES, M.D., Professor of Anatomy, University of Maryland, *Green and Lombard Streets, Baltimore, Md.*

SMITH, M. DEFOREST, A.B., M.D., Assistant in Neurology, Columbia University, *437 West 59th Street, New York City.*

SMITH, PHILIP EDWARD, M.S., Ph.D., *Department of Anatomy, University of California, Berkeley, Calif.*

SNOW, PERRY G., A.B., M.D., Dean and Professor of Anatomy, School of Medicine, *University of Utah, 1031 South 14th East Street, Salt Lake City, Utah.*

SPITZKA, EDWARD ANTHONY, M.D., *63 East 91st Street, New York, N. Y.*

STEENSLAND, HALBERT SEVERIN, B.S., M.D., Professor of Pathology and Director of the Pathological Laboratory, College of Medicine, Syracuse University, *309 Orange Street, Syracuse, N. Y.*

STEWART, CHESTER A., A.M., Assistant in Anatomy, *University of Minnesota, Minneapolis, Minn.*

STILES, HENRY WILSON, M.D., Professor of Anatomy, College of Medicine, Syracuse University, *309 Orange Street, Syracuse, N. Y.*

STOCKARD, CHARLES RUPERT, M.S., Ph.D. (Secretary-Treasurer '14), Professor of Anatomy, *Cornell University Medical College, New York, N. Y.*

STOTSENBURG, JAMES M., M.D., Instructor in Anatomy, *Wistar Institute of Anatomy and Biology, Philadelphia, Pa.*

STREETER, GEORGE L., A.M., M.D., Research Associate in Embryology, Carnegie Institution, *Johns Hopkins Medical School, Baltimore, Md.*

STROMSTEN, FRANK ALBERT, D.Sc., Assistant Professor of Animal Biology, University of Iowa, *943 Iowa Avenue, Iowa City, Iowa.*

STRONG, OLIVER S., A.M., Ph.D., Instructor in Anatomy, Columbia University, *437 West 59th Street, New York, N. Y.*

STRONG, REUBEN MYRON, A.M., Ph.D., Professor of Anatomy, *University of Mississippi, University, Miss.*

SUNDWALL, JOHN, Ph.D., M.D., Professor of Anatomy, *University of Kansas, Lawrence, Kans.*

SUTTON, ALAN CALLENDER, A.B., Student, *Johns Hopkins Medical School, Baltimore, Md.*

SYMINGTON, JOHNSON, M.D., F.R.S., Professor of Anatomy, *Queens University, Belfast, Ireland.*

SWIFT, CHARLES H., M.D., Ph.D., Associate in Anatomy, *Department of Anatomy, University of Chicago, 5632 Maryland Avenue, Chicago, Ill.*

TAINTOR, F. J., M.D., Assistant Professor of Anatomy, *St. Louis University, St. Louis, Mo.*

TAYLOR, EDWARD W., A.M., M.D., Assistant Professor of Neurology, Harvard Medical School, *457 Marlboro Street, Boston, Mass.*

TERRY, ROBERT JAMES, A.B., M.D. (Ex. Com. '08–'12), Professor of Anatomy, *Washington University Medical School, St. Louis, Mo.*

THOMPSON, ARTHUR, M.A., M.B., LL.D., F.R.C.S., Professor of Anatomy, *University of Oxford, Department of Human Anatomy, Oxford, England.*

THORKELSON, JACOB, M.D., *Dillon, Mont.*

THRO, WILLIAM C., A.M., M.D., Assistant Professor of Clinical Pathology, Cornell University Medical School, *28th Street and 1st Avenue, New York, N. Y.*

THÜRINGER, JOSEPH M., M.D., Assistant in Histology and Embryology, *Harvard Medical School, Boston, Mass.*

THYNG, FREDERICK WILBUR, Ph.D., Assistant Professor of Anatomy in the University and Bellevue Hospital Medical College, *338 East 26th Street, New York, N. Y.*

TILNEY, FREDERICK, A.B., M.D., Professor of Neurology, Columbia University, *161 Henry Street, Brooklyn, N. Y.*

TOBIE, WALTER E., M.D., Professor of Anatomy, Medical School of Maine, *3 Deering Street, Portland, Me.*

TODD, THOMAS WINGATE, M.D., Ch.B. (Manc.), F.R.C.S. (Eng.), Professor of Anatomy, *Medical Department Western Reserve University, Cleveland, Ohio.*

TRACY, HENRY C., A.M., Ph.D., Professor of Anatomy, Marquette Medical School, *Fourth and Reservoir Street, Milwaukee, Wis.*

TUPPER, PAUL YOER, M.D., Clinical Professor of Surgery, Washington University Medical School, *Wall Building, St. Louis, Mo.*

WAITE, FREDERICK CLAYTON, A.M., Ph.D., Professor of Histology and Embryology, Western Reserve University School of Medicine, *1353 East 9th Street, Cleveland, Ohio.*

WALKER, GEORGE, M.D., Instructor in Surgery, *Johns Hopkins University, corner Charles and Center Streets, Baltimore, Md.*

WALLIN, IVAN E., B.S., M.A., Assistant Professor of Anatomy, *Marquette University School of Medicine, Milwaukee, Wis.*

WARREN, JOHN, A.B., M.D., Associate Professor of Anatomy, *Harvard Medical School, 240 Longwood Avenue, Boston, Mass.*

WATERSTON, DAVID, M.A., M.D., F.R.C.S.Ed., Butte Professor of Anatomy, *University of St. Andrews, St. Andrews, Fife, Scotland.*

WATKINS, RICHARD WATKIN, B.S., Assistant in Anatomy, *University of Chicago, Chicago, Ill.*

WATT, JAMES CRAWFORD, B.A., M.B., Lecturer in Anatomy, *University of Toronto, 20 Hawthorne Avenue, Toronto, Canada.*

WEED, LEWIS HILL, A.M., M.D., Associate in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

WEIDENREICH, FRANZ, M.D., a.o. Professor and Prosector of Anatomy, *19 Vogesen Street, Strassburg, i. Els. Germany.*

WERBER, ERNEST I., Ph.D., Sessel Research Fellow, *Osborn Zoological Laboratory, Yale University, New Haven, Conn.*

WEST, CHARLES IGNATIUS, M.D., Associate Professor of Anatomy, Medical Department of Howard University, *924 M Street N. W., Washington, D. C.*

WEST, P. A., B.A., *Johns Hopkins Medical School, Baltimore, Md.*

WEST, RANDOLPH, A.M., Student, College of Physicians and Surgeons, Columbia University, *437 West 59th Street, New York, N. Y.*

WHEELER, THEODORA, A.B., Medical Student, *Johns Hopkins Medical School, Baltimore, Md.*

WHITE, HARRY OSCAR, M.D., Professor of Anatomy, Histology and Embryology, Medical Department, University of Southern California, *516 E. Washington Street, Los Angeles, Calif.*

WHITEHEAD, RICHARD HENRY, A.B., M.D., LL.D., Professor of Anatomy and Dean of Medical Department, *University of Virginia, University P. O., Va.*

WILDER, HARRIS HAWTHORNE, Ph.D., Professor of Zoölogy, *Smith College, Northampton, Mass.*

WILLIAMS, STEPHEN RIGGS, A.M., Ph.D., Professor of Zoölogy and Geology, Miami University, *300 East Church Street, Oxford, Ohio.*

WILLARD, WILLIAM A., A.M., Ph.D., Professor of Histology and Embryology, *University of Nebraska, College of Medicine, 42d Street and Dewey Avenue, Omaha, Neb.*

WILSON, J. GORDEN, M.A., M.B., C.M. (Edin.), Professor of Otology, Northwestern University Medical School, *2437 Dearborn Street, Chicago, Ill.*

WILSON, JAMES THOMAS, M.B., F.R.S., Challis Professor of Anatomy, *University, Sydney, Australia.*

WILSON, LOUIS BLANCHARD, M.D., Director of Laboratories, Mayo Clinic, *830 West College Street, Rochester, Minn.*

WISLOCKI, GEORGE BERNAYS, A.B., Student, *Johns Hopkins Medical School, Baltimore, Md.*

WITHERSPOON, THOMAS CASEY, M.D., *307 Granite Street, Butte, Mont.*

WORCESTER, JOHN LOCKE, M.D., Instructor in Anatomy, University of Michigan, *1214 Willard Street, Ann Arbor, Mich.*